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AN EVALUATION OF THE EFFECTIVENESS OF PSYCHOLOGICAL TESTS USED IN SELECTING RECRUITS FOR TRAINING AT THE UNITED STATES MARINE CORPS COMMUNICATION SCHOOLS

BY

EDWARD RICHARD GILBERT

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AN EVALUATION OF THE EFFECTIVENESS OF PSYCHOLOGICAL TESTS USED IN SELECTING RECRUITS FOR TRAINING AT THE UNITED STATES MARINE CORPS COMMUNICATION SCHOOLS

A THESIS
SUBMITTED TO THE GRADUATE SCHOOL
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
for the degree
MASTER OF ARTS

DIVISION OF CORRELATED STUDIES

By
EDWARD RICHARD GILBERT

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INTRODUCTION[1]

Psychological testing. The development and application of psychological testing for practical purposes is, from the historical point of view, in its relative infancy. Scott, Clothier, and Spriegel (21, p. 230 ff) outline the progress of applied psychology from the beginning and classic work of Alfred Binet in 1905, through the rejection of Binet's plan for the testing of the soldiers of France in 1910; the creation of the first testing center for selecting motor transport drivers by the German army in 1915; to the accelerated development of psychological testing in the United States, created by the demand for the rapid development of an efficient civilian army in World War I. In classifying, assigning, training, rating, and promoting the soldiers and officers of this army, some 20 performance tests, 18 picture tests, and 40 oral tests were used. After the war, reports of the success of this work stimulated business and industry to use and expand these techniques to their individual needs. Table I illustrates the growth of this expansion during the period 1925 to 1947.

In World War II the armed forces of this country, facing the problem of providing technicians in huge numbers, and to satisfactorily place millions of individuals in the right military position, employed psychological testing techniques in an unprecedented number. According to Davis (9, p. 3) over 9,750,000 men, exclusive of the National Guard,

---

[1] Appreciation is expressed to Dr. I. A. Berg for his assistance, and to those officers at Headquarters, U.S. Marine Corps, who provided the statistical data for this project.

TABLE I

GROWTH OF PSYCHOLOGICAL TESTING IN BUSINESS

Year	Investigating source	Percentage of firms using tests.
1925	Viteles and Thompson.	4.5
1930	Scott, Clothier and Mathewson.	7
1936	National Industrial Conference Board.	7
1940	Scott, Clothier, Mathewson and Spriegel.	11
1940	National Industrial Conference Board.	16
1945	*The American Psychologist.*	50
1946	Dartmouth College.	56
1947	Scott, Clothier and Spriegel.	60

Source: Scott, Clothier and Spriegel, *Personnel Management*, New York: McGraw-Hill, 1949, p. 257.

were individually classified and assigned in the Army alone. Scott, Clothier, and Spriegel (21, p. 238 f) state that 4,032,914 men were tested and 24,233,142 tests were administered in our armed services during the single year of 1944. In this same year the Bureau of Naval Personnel administered some 9,000,000 tests to 1,250,000 people, while the Army Air Forces gave 10,000,000 tests to 400,000 people (2).

The studies illustrating the utilization of psychological tests for selection and placement are many and varied. Super (23, p. 347 f) describes a number of studies concerning the successful selection of medical students through the use of test batteries designed for that purpose. Griffin and Borow (11) report correlations as high as .79 in discriminating value for the Engineering and Physical Science Aptitude Test at the Pennsylvania State College. Brush (5) studied mechanical ability as a factor in engineering aptitude and concluded that achievement tests predict success in this study better than tests of mechanical ability. In a study of success and failure among student nurses, Berg (3) found that data from a test battery predicted the poor scholarship of the number of nurses later dropped from training because of low scholarship. Jacobsen (15) determined the validity of tests as predictors of success in the aircraft trades. Adams (1) made a critical study of some 23 prelaw and mental tests to determine the best predictors for colleges of law. Super (23, p. 350 ff) reports many studies of successful test batteries for the selection and placement of psychologists, salesmen, scientists, and teachers. In a study of 89 pressmen apprentices, Hall (12) found that the use of the Minnesota Form Board Test was a significant aid in selection. Seventy-five percent of the inferior workers stood below the established critical

score, while only six percent of the workers of average skill, and five percent of the superior workers, fall below this score. Wadsworth (27) reports that testing techniques in a large public utility company lowered the percentage of problem employees from 29 to five and one-half per cent after the testing program was adopted. At the same time, the number of outstanding employees hired was raised from 22 per cent to 33 per cent, while the number of satisfactory employees was raised from 49 to 61.5 per cent. Any examination of the available literature clearly indicates the increasing importance attached to the development and application of psychological testing within business, industry, education, and the armed services.

Testing in the Naval Service. The Marine Corps, as an integral part of the Naval Service, is concerned with problems similar in nature to the problems of both the Army and the Navy. Quite logically the procedures used for the selection and classification of personnel during the World War II period were adapted from the available methods and materials of the Army and Navy. Davis (9, p. 24) reports:

> At the recruit depots at San Diego and Parris Island, the men were given a group of tests. They were interviewed individually and qualification cards filled out. An adaption of the Army Soldier's Qualification Card was employed for this purpose and the data recorded were similar to those obtained from men entering the Army. The test scores entered on the card were those derived from the Army General Classification Test, the Army Mechanical-Aptitude Test, and a radio code-aptitude test. The Navy Radio-Technician Selection Test was administered to some men for whom it seemed appropriate, and the resulting scores were also entered on the qualification card.

The procedure followed by the Navy was quite similar but made use of a much longer battery of tests. The author (9, p. 15), in discussing this procedure, writes:

> Literate men accepted by the Navy were sent to recruit training centers where a series of tests including the Navy Basic Test Battery was administered to them in order to determine to which naval training school or specialized technical-training course some of them should be sent. Qualifying scores were established for over forty-six training programs for enlisted personnel. The tests included in the Basic Test Battery were:
>
> General Classification Test
> Reading Test
> Arithmetical-Reasoning Test
> Mechanical-Aptitude Test
> Mechanical-Knowledge Test (Mechanical Score)
> Mechanical-Knowledge Test (Electrical Score)
> Clerical-Aptitude Test
> Spelling Test
> Radio Code Test-Speed of Response.

This background is emphasized because during this period a great variety of manpower was made available to the Naval Service. From this reservoir could be tapped quantities of personnel with talent and experience in the field of communications. Yet despite the large population from which to select, Stuit (22, p. 112) says: "Attrition in radio schools has always been higher than in most other type of training for enlisted personnel ..." He further reports (22, p. 118 f) that:

> The training for radio technicians has been one of the longest and most rigorous of the naval programs for enlisted personnel. In the early months of the war only men who had some previous experience in radio and electricity were accepted for training. To insure the maintenance of personnel quality the Radio Technician Selection Test, in large part a measure of achievement in radio material, was developed. As the supply of men experienced in radio diminished, and it became necessary to select for training from the general population, the early forms of the Radio Technician Selection Test decreased in validity.

During World War II the Navy supplemented the training at naval radio material schools by contracting with five elementary radio training institutions. In a study at one of these schools, the Utah State

Agricultural College, Frandsen and Hadley (10) administered six scales to six training companies of sailors and marines, numbering 95 to 116, during the period March to August of 1942. The tests used were:

Mental Ability Test.
USAC Mathematics Ability.
Technical Information in Industrial Mathematics.
Technical Information in Electricity.
Jr. High School Electricity Test.
USAC Radio Interest Questionnaire.

As a result of this investigation the experimenters conclude:

> The most effective and economical combination of tests in a multiple regression equation for predicting average achievement would be comprised of either one of the mathematics test *and* the Technical Information in Electricity Test. To add the intelligence test and/or interest questionnaire would not improve the precision of the prediction.

Lawshe and Thornton (17) developed a battery of tests at the Naval Training School for Electricians, located at Purdue University. The original test battery, administered at the basic Naval Training Station, was supplemented with three tests. These tests were a 15-minute mental alertness test, a test designed to evaluate an individual's ability to read simple measurements and solve simple arithmetical problems, and a test designed to measure practical electrical information. The tests were given to some 600 trainees prior to actual participation in the 15-week training course. With grade-point average as the criterion, the authors reported that the predicted grade-point averages correlated .82 with the actual score.

Hadley (13) in a separate study at the Utah State College Naval Radio Training School, compared groups composed of 275 sailors and 345 marines on the basis of tests and achievement. The writer states

that, "... it is evident that there would be fewer instances of failure if selection for this type of training was made upon the basis of tests in mathematical and electrical knowledge. Other factors would seem of secondary importance although experience, college training, and especially the desire to study radio are definitely advantageous."

Communications in military science. The critical role played by the science of communications in the conduct of World War II cannot be questioned. Its value was effectively demonstrated in all theaters of operations. Given relative equality of all other military equipment, technical and tactical skill of command, personnel and will to fight, that force with superior communications will surely emerge the victor in combat. Superior communications requires both effective materiel and effective personnel to operate, repair, and maintain the variety of signal and electronics equipment. Within the organic marine division of the Fleet Marine Force there are 1,038 radios, 1,219 telephones, 216 switchboards, and 1,957 miles of telephone wire, plus radar, sound-ranging equipment, and other electronics devices, which require some 2300 enlisted marines to operate this equipment. The field of military communications continues to grow, and the requirements for skilled communication specialists will continue to grow in the foreseeable future.

Requirements of the present. The studies cited, it is emphasized, relate to the enlisted population of the World War II period. During that period this population could provide a large number of men skilled or experienced in radio, telephone, or in some associated field. This source of potential communication and electronic

specialists was quickly exhausted and the continual demands for this type of personnel require accurate predictors for selecting trainees for the various special schools from a heterogeneous population. This situation was paralleled in the Marine Corps.

While the numerical requirements for communicators is far less at the present because of the reduction in over-all strength from war to peace-time organization, the requirements on a percentage basis represents an increase of approximately 20 per cent, due to the additional uses of communications and electronic facilities.[2] The present source of available manpower is limited to the volunteer enlistments of the Corps. According to the Research Division, Personnel Department, Headquarters, U.S. Marine Corps, these men represent a rather homogeneous group having a mean age of 18.89 and a standard deviation of 1.88 years.

During the year 1949, approximately 100 out of 1100 men failed to qualify for successful graduation in communication courses offered to recruits of the Marine Corps. These failures represent a fiscal loss in training costs plus the loss of the services of these men in some assignment where they might be more effectively placed. Furthermore, this does not account for the loss of a like number of men who might have qualified as competent radio and telephone communication personnel in place of those that failed to qualify. It is obvious that current selection techniques should be capable of identifying those individuals that possess the necessary physical, mental, and

---

[2] This ratio is based upon the difference in the number of communication specialists required in the organic World War II division and the current "war strength" organization of the Fleet Marine Force division.

psychological qualities necessary for successful completion of the assigned course of instruction.

The possibilities of effective selection practice, based upon a sound program of psychological testing, is reported by Davis (9 p. 38 f), who writes:

> A study made by aviation psychologists in the office of the Air Surgeon illustrates the degree to which it is possible to select men who will be successful in a course of training. If applicants for aviation-cadet training in the summer of 1943 had been accepted without aptitude tests, it would have been necessary to have started 397 men in pilot pre-flight school in order to have obtained 100 graduates of advanced pilot training schools. That is, only about one-fourth of unselected applicants for aviation-cadet training (in the summer of 1943) could have been expected to get their pilot's wings. Yet training facilities and personnel would have had to be provided for the unsuccessful three-fourths until they were eliminated. On the other hand, of the applicants admitted to pilot pre-flight school in the summer of 1943 who obtained passing scores on the aptitude tests then in current use (the Aviation Cadet Qualifying Examination and the Aircrew Classification Battery), a much smaller percentage had to be eliminated. In fact to obtain 100 graduates of advanced pilot training schools, it was necessary to start only 155 selected men in pilot pre-flight school.

Current recruit selection in the Marine Corps. Volunteers are selected for enlistment in the regular Marine Corps on the basis of established minimum mental, moral and physical qualifications. At subdistrict headquarters, the applicant is given a screening test of 50 test questions. Each question has four plausible answers of which only one is correct. Fifteen minutes is allowed for reading the directions and selecting the answers. To qualify, the applicant must score 33 out of the possible 50 points. At the district recruiting headquarters, the applicant takes the Recruiting Test, consisting of 150 questions, ten of which are sample questions. For selection the appli-

cant must receive a raw score of 41 which is equivalent to a General Classification Test score of 90. The average GCT score for marine recruits in 1949 was 108 points. The "Screening Test" is not administered to applicants who apply directly to District Headquarters.

Depending upon geographic location of the various enlistment centers, these volunteers are sent to the recruit depot at Parris Island or to the depot at San Diego, where the recruit receives intensive training in the military requirements of the individual marine. During this "boot" training period the recruits are given a test battery composed of the following tests:

General Classification Test
Clerical Aptitude Test
Radio Code Test, Speed of Response
Radio Technician Selection Test.

The former Mechanical Aptitude Test has been declared obsolete and its use has been discontinued. The present General Classification Test consists of four subtests which give individual subtest scores as well as a total test score. The four subtests evaluate the areas of (1) reading and vocabulary, (2) arithmetic computation, (3) arithmetic reasoning, and (4) pattern analysis. For assignment purposes the score resulting from the Pattern Analysis Subtest is used in place of a Mechanical Aptitude Test score. The Radio Code Test is administered to all recruits who attain a score of 90 or more in the General Classification Test, and the Radio Technician Selection Test is given to recruits scoring over 100 in the General Classification Test.

These scales are administered by marine non-commissioned officers trained and qualified in the administration of these specific instruments. Test results are recorded on a post-war qualification

form together with personal information concerning the individual marine.[3] One copy of this form becomes part of the Service Record Book of the individual, while the second copy is forwarded to Headquarters, U.S. Marine Corps, for record purposes.

On the basis of this information and the individual desires of the recruit, assignment to a duty station is made. Selection of recruits meeting specified qualifications is made within quota limits for the several special training schools. For selection to communication school for radio operator's training the recruit must score a minimum of 130 in the Radio Code Test. For selection to pre-radio training the recruit must score a minimum of 35 in the Radio Technician Selection Test and 110 in the General Classification and Pattern Analysis Tests. The recruit must attain a minimum score of 90 in the General Classification and Pattern Analysis Test for assignment to field telephone training.[4]

The Marine Corps Communication Schools. For the purpose of this study the title Marine Corps Communication Schools actually refers to two separate schools: the Signal Battalion, Marine Barracks, Camp Pendleton, Oceanside, California; and the U.S. Naval School (Electronics Materiel), Naval Training Center, Great Lakes, Illinois. While these schools offer a wide variety of communication and electronic courses, such as those in radar, radar-repair, aviation electronics, cryptography, automatic telephone system maintenance, cable splicing, and teletype mechanics, this study is concerned with courses specifically designed to initiate recruits into the communication speciality.

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[3] See Appendix A, p. 71.
[4] Source: Marine Corps General Order No. 42, dated September 26, 1949.

The curriculum offered by the two training centers is summarized as follows:[5]

1. Radio Operators' (low speed) Course, Signal Battalion, Marine Barracks, Camp Pendleton, Oceanside, California.
    - 1.1 Course description - Course includes instruction in radio procedure, basic typing, International Morse Code, preventive maintenance, tele-typewriter operating procedure and message center procedure.
    - 1.2 Length of course - 19 weeks.
    - 1.3 Starting interval - Every four weeks.
2. Field Telephone Course, Signal Battalion.
    - 2.1 Course description - Course includes instruction in the principles of electricity, telephony and telegraphy, field wire systems, and practice of installation, repair, and maintenance of telephone and telegraph equipment used by the Marine Corps.
    - 2.2 Length of course - 14 weeks.
    - 2.3 Starting interval - Every six weeks.
3. Pre-Radio (Electronic Materiel) Course, U.S. Naval Training Center, Great Lakes, Illinois.
    - 3.1 Course description - Course includes instruction in radio mechanics, fundamentals of electricity, applied mathematics, alternating current circuits and electrical machinery. Includes laboratory instruction in identification of radio parts and symbol sketching, radio transmitters and receivers.
    - 3.2 Length of course - 26 weeks.
    - 3.3 Starting interval - Every two weeks.
    - 3.4 After successful completion of this course graduates are assigned to advanced training at the Signal Battalion, Marine Barracks, Camp Pendleton, in the Radio Repairmans' Course or the Radar Repairmans' Course.

Statement of the problem. In accordance with the National Security

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[5] Ibid.

Act of 1947 and a statement of the functions of the Armed Forces and the Joint Chiefs of Staff, issued by the Secretary of Defense on April 27, 1948, one mission of the Marine Corps is:[6] "To be prepared, in accordance with the integrated joint mobilization plans, for the expansion of the peacetime components to meet the needs of war." In order to expedite the selection and placement of personnel in critical billets, should this expansion become necessary, it is essential that the most effective selection methods be devised during times of peace. The purpose of this study is to determine the effectiveness of the Radio Code Test, the General Classification Test, The Pattern Analysis Test, and the Radio Technician Selection Test, in predicting the success of Marine Corps recruits selected for training at the Marine Corps Communication School. Recommendation for the improvement of future selection techniques will be made on the basis of these findings.

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[6] Source: The Marine Corps Manual, Vol. I, Administration, 1949.

PROCEDURES

Description of the test battery. The selection of recruits for communication training is based, primarily, upon the attainment of certain minimum or critical scores on selected tests of the basic test battery administered during recruit training. The number of items and the time-limits for test purposes of the General Classification Test, the Radio Code Test, and the Radio Technician Selection Test are summarized in Table II. The established critical scores for selection to the communication specialities are illustrated in Table III. Table IV shows the published reliabilities and the standard deviations of the population norms of these tests.

Collection of the experimental data. Administrative instructions of the Marine Corps require commanding officers of all specialist schools to submit school personnel reports to Headquarters, U.S. Marine Corps. These reports list the names of individual students, their final grade-point average, sub-course grades, and indicate those individuals who fail to satisfactorily complete the course. A random sample of 300 communication school students was selected from these reports, with 100 cases each to represent the Radio Operators', the Pre-Radio, and the Field Telephone Course. The sample was taken from the period January to December of 1949 to insure a consistent curricula and selective criteria.

When this sample was selected, individual qualifications were secured from the Machine Records Section of Headquarters, Marine

TABLE II

NUMBER OF TEST ITEMS AND TIME LIMITS FOR TESTS USED IN RECRUIT SELECTION

Nature of the test	Number of test items	Time allowed
General Classification Test............	228	150 min.
Reading and Vocabulary............	56	25
Arithmetic computation............	56	15
Arithmetic reasoning..............	56	35
Pattern analysis..................	60	20
Radio Code Test, Speed of Response*....	150	13 min.
Radio Technician Selection Test........	80	75 min.

* This test is of an audio nature and consists of a phonograph record.

SOURCE: From information supplied by the Research Division, Personnel Department, Headquarters, U.S. Marine Corps.

TABLE III

CRITICAL SCORES FOR TESTS USED IN RECRUIT SELECTION FOR COMMUNICATION SCHOOL

Test title	Field Telephone Course	Pre-Radio Course	Radio Operator Course
General Classification Test........	90	110	100
Pattern Analysis Test..............	90	110	100
Radio Code Test, Speed of Response........................	none	none	130
Radio Technician Selection Test............................	none	35	none

SOURCE: From information supplied by the Research Division, Personnel Department, Headquarters, U.S. Marine Corps, March 1950.

TABLE IV

RELIABILITIES AND STANDARD DEVIATIONS OF TESTS USED IN RECRUIT SELECTION

Test title	Coefficient of Reliability	Standard Deviation
General Classification Test	.91	20.0
Pattern Analysis Test	.90	18.0
Radio Code Test, Speed of Response	.87	19.0
Radio Technician Selection Test	.89	19.5

SOURCE: From information supplied by the Research Division, Personnel Department, Headquarters, U.S. Marine Corps.

Corps. Through the available machine records the General Classification Test score, a Mechanical Aptitude Test score, the Radio Code Test score, and the Radio Technician Selection Test score, were obtained as provided by the original records. A certain amount of difficulty was experienced in that the records of this group were not complete on the machine records at the time the sample was drawn. Additional test scores were obtained by drawing individual case files and checking this file for test information.

A disturbing factor in the collection of the data was the fact that the records contained a Mechanical Aptitude Test score while this test had been declared obsolete and its use discontinued January 1, 1949. Investigation disclosed that the Pattern Analysis Sub-test of the General Classification Test had been used to replace the Mechanical Aptitude Test, and the Pattern Analysis Test score entered on the records in place of the Mechanical Aptitude score. This sub-test is actually an improvement on parts of the Mechanical Aptitude Test, and measures skill in the mental manipulation of spatial relations and the visualization of three-dimensional forms. It is considered by the Army to be an equal substitute.[7]

The Criterion. The particular problem of this study is to evaluate the effectiveness of certain psychological tests used in selecting Marine Corps recruits for training at the Communication School. Thorndike (25 p. 119) advises, "Any program of research in personnel selection implies the testing of the selection instruments against some standard of subsequent success on the job in question." Effectiveness, then, is realized by the relative value of the test

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7. Source: Training Manual 12-260, War Department, April 1946.

battery in predicting the success or failure of the marine in completing an assigned course. It must be remembered that the study is concerned with school attainment and not with the degree of post-school success in the communication specialities.

Grades are assigned at the school largely on the basis of objective testing, standardized at the school, and to a less degree by instructors' ratings of certain field and laboratory work. The writer assumes, therefore, a reasonable level of validity and reliability in the grading system, and the grade-point average was selected as the criterion measure. In the case of the Radio Operators' Course, a further criterion, the rate of sending and receiving radio code, was adopted for that speciality. Thorndike (26, p. 154) writes, "... in most cases the reliability of academic grades will be quite sufficient for personnel research problems." To determine the relative predictive value of the tests employed, the criterion was used in the following manner; passed and failed, top and bottom quarter of student proficiency, and grade-point average relationship.

The methodology of analysis. Validity is determined by the degree of correlation between a test and its criterion. In turn the test will be a successful predictor of the criterion if a satisfactory degree of correlation can be demonstrated to exist with the criterion. The plan for the statistical treatment of the data to determine the validity that may exist between the tests and the criterion, is outlined below:

1. Determination of direct relationships.
    1.1 Relationship of General Classification Test (GCT)

scores, and the relationship of Pattern Analysis Test (PAT) scores, to grade point averages in the Field Telephone, Pre-Radio, and Radio Operators' Course.

1.2 Relationship of Radio Code Test (RCT) scores to grade-point averages in the Radio Operators' Course.

1.3 Relationship of the Radio Technician Selection Test (RTST) scores to grade-point average in the Field Telephone and Pre-Radio Course.

1.4 Relationship of GCT scores, and the relationship of PAT scores, to success or failure in the Field Telephone, Pre-Radio, and Radio Operators' Course.

1.5 Relationship of GCT scores, and the relationship of PAT scores, by comparison of test quarter standing to top and bottom quarter standing in the distribution of grades in the Field Telephone, Pre-Radio, and Radio Operators' Course.

1.6 Relationship of RCT scores by comparison of quarter standing to top and bottom quarter grade distribution in the Radio Operators' Course.

1.7 Relationship of RTST scores by comparison of quarter standing to top and bottom quarter grade distribution in the Pre-Radio Course.

2. Determination of simple correlations.

2.1 Correlation of GCT scores with grade-point averages in the Field Telephone, Pre-Radio, and Radio Operators' Course.

2.2 Correlation of PAT scores with grade-point averages in the Field Telephone, Pre-Radio, and Radio Operators' Course.

2.3 Correlation of RCT scores with grade-point averages and the qualified rate of sending and receiving radio-code in the Radio Operators' Course.

2.4 Correlation of RTST scores to grade-point averages in the Field Telephone and Pre-Radio Course, and with grades in the Radio Equipment subcourse of the Radio Operators' Course and the Electricity subcourse of the Field Telephone Course.

3. Determination of intercorrelations of tests in the test battery.

4. Determination of partial correlations holding the GCT score constant.

5. Determination of multiple correlations of the tests in the test battery for the Field Telephone, the Pre-Radio, and the Radio Operators' Course.

The subtests of the General Classification Test yield a separate score on the specific abilities of (1) reading and vocabulary, (2) arithmetic computation, (3) arithmetic reasoning, and (4) pattern analysis. The first three scores of this test have not been used in the tremtment of the data. It is realized that some significant relationship may exist between these elements and the established criterion. Unfortunately these additional subtest scores were not available to the writer, and could not be used therefore for the purpose of the study.

RESULTS

A random sample of 100 cases each was obtained for the three communication school courses. Certain test or criterion data were not available in all cases. Table V summarizes the data available for statistical treatment in this study. In addition to the sample, data were obtained on all marines failing in the 1949 school year to complete the communication courses under consideration. A significant number of scores were available for the General Classification and Pattern Analysis Test only. Grade-point standings were not available for the individuals in this group.

The scatter diagrams, Appendix B, Figures 1 through 13, show the direct relationship between the various tests and the indicated criterion.

The relationship of test scores to success or failure, as determined from the sample, is shown in Tables VI through XI. Tables XII through XIX show the relation of test scores to final standing by comparing the top and bottom quarter standing in grade-point average with quarter standing in test scores.

Table XX compares the test score average of marines successfully completing the prescribed communication course, with the average of the group failing the course for the year 1949.

Tables XXI through XXIII summarize the means, standard deviations, and standard errors of the means, of the sample data for each of the three courses. All statistical calculations were made according to

the methods described by Croxton and Cowden (8).

Correlations of test scores with final standings, and standard errors of estimate are summarized on Tables XXIV, XXV, and XXVI.

Table XXVII shows the intercorrelations between certain test scores. Partial correlations are shown on Table XXVIII. Table XXIX summarizes the multiple correlations of test scores and final standings for the three communication courses.

While scores for the individual's grade-point average were obtained in the sample of the Field Telephone and the Radio Operators' Course, final standings for individuals in the Pre-Radio Course were available only as class-position scores. This position-score was indicated by the number the individual ranked in class out of the total number.[8] To use this data statistically, the relative standing of each individual on a base of 100 was first computed. A normal distribution of grades was assumed on the basis of the grading methods used at the communication school (18 p. 59 f). The ratio of the deviation of the score from the mean, to the standard deviation of the distribution, was found for each class group by reference to a table showing areas under the normal curve (8 p. 873). Negative numbers were avoided by using a modified Z-score with a mean of 50.

For the purpose of brevity in table construction, the following abbreviations have been used:

GCT.....General Classification Test
PAT.....Pattern Analysis Test
RCT.....Radio Code Test
RTST....Radio Technician Selection Test.

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[8] Example: The top ranking man in a class of 134 marines would be scored - 1/134

TABLE V

SUMMARY OF TEST DATA AVAILABLE FROM A RANDOM SAMPLE OF 100 CASES*

Course and test title	Number of scores
Field Telephone Course:	
General Classification Test	94
Pattern Analysis Test	94
Radio Technician Selection Test	21
Radio Operators' Course:	
General Classification Test	81
Pattern Analysis Test	81
Radio Technician Selection Test	30
Radio Code Test	73
Pre-Radio Course:	
General Classification Test	87
Pattern Analysis Test	87
Radio Technician Selection Test	74

*Includes failures.

TABLE VI

RELATION OF GENERAL CLASSIFICATION TEST SCORES OF 94 MARINES TO SUCCESS OR FAILURE IN SATISFACTORILY COMPLETING THE FIELD TELEPHONE COURSE

GCT score	Number of successes	Number of failures	Total number
140 - 144	2	0	2
135 - 139	3	0	3
130 - 134	3	0	3
125 - 129	6	0	6
120 - 124	11	0	11
115 - 119	8	1	9
110 - 114	15	0	15
105 - 109	14	0	14
100 - 104	14	1	15
95 - 99	5	3	8
90 - 94	6	2	8
Total	87	7	94

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[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]

TABLE VII

RELATION OF PATTERN ANALYSIS TEST SCORES OF 94 MARINES TO SUCCESS OR FAILURE IN SATISFACTORILY COMPLETING THE FIELD TELEPHONE COURSE

PAT score	Number of successes	Number of failures	Total number
136 - 140	2	0	2
131 - 135	6	0	6
126 - 130	9	0	9
121 - 125	5	1	6
116 - 120	10	0	10
111 - 115	13	0	13
106 - 110	16	0	16
101 - 105	11	2	13
96 - 100	6	0	6
91 - 95	6	3	9
86 - 90	3	1	4
Total	87	7	94

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TABLE VIII

RELATION OF GENERAL CLASSIFICATION TEST SCORES OF 87 MARINES TO SUCCESS OR FAILURE IN SATISFACTORILY COMPLETING THE PRE-RADIO COURSE

GCT score	Number of successes	Number of failures	Total number
150 - 154	1	0	1
145 - 149	3	0	3
140 - 144	8	0	8
135 - 139	8	2	10
130 - 134	12	0	12
125 - 129	21	2	23
120 - 124	12	3	15
115 - 119	5	1	6
110 - 114	3	5	8
105 - 109	1	0	1
Total	74	13	87

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[illegible]	[illegible]	[illegible]	[illegible] – [illegible]
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TABLE IX

RELATION OF PATTERN ANALYSIS TEST SCORES OF 87 MARINES TO SUCCESS OR FAILURE IN SATISFACTORILY COMPLETING THE PRE-RADIO COURSE

PAT score	Number of successes	Number of failures	Total number
150 - 154	1	0	1
145 - 149	1	0	1
140 - 144	8	1	9
135 - 139	15	2	17
130 - 134	16	3	19
125 - 129	20	2	22
120 - 124	7	3	10
115 - 119	5	2	7
110 - 114	1	0	1
Total	74	13	87

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[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
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TABLE X

RELATION OF GENERAL CLASSIFICATION TEST SCORES OF 81 MARINES TO SUCCESS OR FAILURE IN SATISFACTORILY COMPLETING THE RADIO OPERATORS' COURSE

GCT score	Number of successes	Number of failures	Total number
140 - 149	1	0	1
135 - 139	6	0	6
130 - 134	3	1	4
125 - 129	7	0	7
120 - 124	10	0	10
115 - 119	13	1	14
110 - 114	15	2	17
105 - 109	7	1	8
100 - 104	4	2	6
95 - 99	6	0	6
90 - 94	1	1	2
Total	73	8	81

TABLE XI

RELATION OF PATTERN ANALYSIS TEST SCORES OF 81 MARINES TO SUCCESS OR FAILURE IN SATISFACTORILY COMPLETING THE RADIO OPERATORS' COURSE

PAT score	Number of successes	Number of failures	Total number
135 - 139	3	0	3
130 - 134	6	0	6
125 - 129	6	0	6
120 - 124	14	0	14
115 - 119	10	0	10
110 - 114	12	1	13
105 - 109	8	3	11
100 - 104	5	1	6
95 - 99	5	2	7
90 - 94	3	0	3
85 - 89	0	0	0
80 - 84	1	1	2
Total	73	8	81

TABLE XII

RELATION OF GENERAL CLASSIFICATION TEST SCORES OF 87 MARINES TO FINAL STANDINGS IN THE FIELD TELEPHONE COURSE

Quarter of group in test score	Bottom quarter grades		Top quarter grades	
	Number	Per cent	Number	Per cent
Top quarter	0	0.0	15	68.2
Second quarter	7	31.8	5	22.7
Third quarter	7	31.8	2	9.1
Bottom quarter	8	36.4	0	0.0

TABLE XIII

RELATION OF PATTERN ANALYSIS TEST SCORES
OF 87 MARINES TO FINAL STANDINGS IN THE
FIELD TELEPHONE COURSE

Quarter of group in test score	Bottom quarter grades		Top quarter grades	
	Number	Per cent	Number	Per cent
Top quarter	0	0.0	14	63.6
Second quarter	5	22.7	7	31.8
Third quarter	6	27.3	1	4.6
Bottom quarter	11	50.0	0	0.0

TABLE XIV

RELATION OF GENERAL CLASSIFICATION TEST SCORES OF 74 MARINES TO FINAL STANDINGS IN THE PRE-RADIO COURSE

Quarter of group in test score	Bottom quarter grades		Top quarter grades	
	Number	Per cent	Number	Per cent
Top quarter	3	15.8	9	47.4
Second quarter	3	15.8	7	36.8
Third quarter	4	21.0	2	10.5
Bottom quarter	9	47.4	1	5.5

TABLE XV

RELATION OF PATTERN ANALYSIS TEST SCORES OF 74 MARINES TO FINAL STANDINGS IN THE PRE-RADIO COURSE

Quarter of group in test score	Bottom quarter grades		Top quarter grades	
	Number	Per cent	Number	Per cent
Top quarter	3	15.8	10	52.7
Second quarter	5	26.3	7	36.8
Third quarter	5	26.3	2	10.5
Bottom quarter	6	31.6	0	0.0

TABLE XVI

RELATION OF RADIO TECHNICIAN SELECTION TEST SCORES OF 74 MARINES TO FINAL STANDINGS IN THE PRE-RADIO COURSE

Quarter of group in test score	Bottom quarter grades		Top quarter grades	
	Number	Per cent	Number	Per cent
Top quarter	0	0.0	13	68.4
Second quarter	4	21.0	5	26.3
Third quarter	7	36.8	0	0.0
Bottom quarter	8	42.2	1	5.3

TABLE XVII

RELATION OF GENERAL CLASSIFICATION TEST SCORES OF 73 MARINES TO FINAL STANDINGS IN THE RADIO OPERATORS' COURSE

Quarter of group in test score	Bottom quarter grades		Top quarter grades	
	Number	Per cent	Number	Per cent
Top quarter	0	0.0	11	57.9
Second quarter	1	5.3	5	26.3
Third quarter	6	31.6	3	15.8
Bottom quarter	12	63.1	0	0.0

TABLE XVIII

RELATION OF PATTERN ANALYSIS TEST SCORES OF 73 MARINES TO FINAL STANDINGS IN THE RADIO OPERATORS' COURSE

Quarter of group in test score	Bottom quarter grades		Top quarter grades	
	Number	Per cent	Number	Per cent
Top quarter	2	10.5	12	63.0
Second quarter	3	15.8	4	21.2
Third quarter	5	26.3	3	15.8
Bottom quarter	9	47.4	0	0.0

TABLE XIX

RELATION OF RADIO CODE TEST SCORES OF 73 MARINES TO FINAL STANDINGS IN THE RADIO OPERATORS' COURSE

Quarter of group in test score	Bottom quarter grades		Top quarter grades	
	Number	Per cent	Number	Per cent
Top quarter	1	5.3	12	63.0
Second quarter	3	15.8	4	21.2
Third quarter	5	26.2	1	5.3
Bottom quarter	10	52.7	2	10.5

TABLE XX

RELATION OF AVERAGE TEST SCORES TO SUCCESS OR FAILURE IN THE MARINE CORPS COMMUNICATION SCHOOLS*

Course and test	Success				Failure			
	N	Mean	S.D.	Median	N	Mean	S.D.	Median
Field Telephone Course:								
GCT.........	87	112.4	12.1	111.5	26	103.8	11.5	102.7
PAT.........	87	112.2	12.6	111.6	26	105.3	12.5	102.9
Pre-Radio Course:								
GCT.........	74	129.3	9.0	128.8	51	121.6	9.7	121.3
PAT.........	74	130.9	7.3	131.3	51	126.5	9.9	128.5
Radio Operators' Course:								
GCT.........	73	116.5	11.7	116.3	20	111.6	10.0	110.4
PAT.........	73	115.2	10.3	116.2	20	109.5	15.0	109.3

* Computation of data on failures based upon failure reports of Communication School students for the year 1949. Usable data on failures consisted of 93% of Field Telephone Course failures, 85% of Pre-Radio Course failures, and 74% of Radio Operators' Course failures.

TABLE XXI

SUMMARY OF STANDARD DEVIATIONS AND STANDARD ERRORS OF MEANS OF SAMPLE DATA COMPUTED FOR THE FIELD TELEPHONE COURSE

Nature of data	N	Mean	S.D.	Std. error of M
Final grade-point average................	87	84.2	3.9	0.42
Final grade-point average*...............	21	81.6	3.4	0.79
Electricity Sub-course average................	21	82.4	8.0	1.78
GCT........................	87	112.4	12.1	1.30
PAT........................	87	112.2	12.6	1.36
RTST.......................	21	26.4	4.9	1.09

* Final grade-point average of sample data having RTST scores available for comparison.

TABLE XXII

SUMMARY OF STANDARD DEVIATIONS AND STANDARD ERRORS OF MEANS OF SAMPLE DATA COMPUTED FOR THE PRE-RADIO COURSE

Nature of data	N	Mean	S.D.	Std. error of M
Final class standing*......	74	58.8	9.8	1.15
RTST......................	74	57.1	9.5	1.11
PAT.......................	74	130.9	7.2	0.84
GCT.......................	74	129.3	9.0	1.06

* Final class standings computed in modified Z-scores from numerical position-standing in class.

TABLE XXIII

SUMMARY OF STANDARD DEVIATIONS AND STANDARD ERRORS OF MEANS OF SAMPLE DATA COMPUTED FOR THE RADIO OPERATORS' COURSE

Nature of data	N	Mean	S.D.	Std. error of M
Final grade-point average	73	84.5	4.9	0.06
GCT	73	116.5	11.7	1.37
PAT	73	115.2	10.3	1.21
RCT	73	140.7	7.1	0.83
RCT*	55	139.0	7.0	0.95
RTST	30	33.2	6.5	1.21
Code sending speed in words per minute	55	14.7	1.4	0.20
Code receiving speed in words per minute	55	20.7	2.2	0.29
Radio Equipment Sub-course average	30	84.2	7.9	1.44

*RCT scores for available sample of sending and receiving rate qualifications.

TABLE XXIV

CORRELATIONS OF TEST SCORES AND FINAL STANDINGS IN THE FIELD TELEPHONE COURSE

Test and criterion	N	Sy	r^2	r
GCT scores with grade-point average	87	3.34	26.0%	.51
PAT scores with grade-point average	87	3.53	18.7%	.43
RTST scores with Electricity Sub-course average	21	6.65	26.0%	.52
RTST scores with grade-point average	21	2.88	30.1%	.55

TABLE XXV

CORRELATIONS OF TEST SCORES AND FINAL STANDINGS IN THE PRE-RADIO COURSE*

Test and criterion	N	Sy	r^2	r
GCT scores with final standing............................	74	8.96	15.7%	.40
PAT scores with final standing............................	74	3.68	43.7%	.66
RTST scores with final standing............................	74	3.16	31.7%	.56

* Final class standings computed in modified Z-scores from numerical position-standing in class.

TABLE XXVI

CORRELATIONS OF TEST SCORES AND FINAL STANDING IN THE RADIO OPERATOR'S COURSE

Test and criterion	N	Sy	r^2	r
GCT scores with grade-point average	73	4.31	23.7%	.49
FAT scores with grade-point average	73	4.13	7.7%	.28
RCT scores with grade-point average	73	4.15	13.9%	.37
RCT scores with rate of receiving code	55	1.67	59.8%	.77
RCT scores with rate of sending code	55	1.24	26.3%	.51
RTST scores with Radio Equipment Sub-course average	30	7.22	13.4%	.37

TABLE XXVII

SUMMARY OF INTERCORRELATIONS OF COMPARABLE TEST SCORES

Course and test	N	GCT*	PAT*
Field Telephone Course:			
GCT	87	-	.35
Pre-Radio Course:			
GCT	74	-	.30
RTST	74	.19	.11
Radio Operators' Course:			
GCT	73	-	.32
RCT	73	.13	-.12

* Coefficient of correlation (r).

TABLE XXVIII

SUMMARY OF PARTIAL CORRELATIONS COMPUTED HOLDING GENERAL CLASSIFICATION TEST SCORES CONSTANT

Course, test, and criterion	N	$r^2_{12.3}$	$r_{12.3}$
Field Telephone Course:			
PAT score with grade-point average........	87	24.0%	.49
Pre-Radio Course:			
PAT score with grade-point average........	74	38.4%	.62
RTST score with grade-point average*......	74	64.0%	.80
Radio Operators' Course:			
PAT score with grade-point average........	73	2.3%	.15
RCT score with grade-point average........	73	12.9%	.36

* Final standings for Pre-Radio Course computed as modified Z-scores.

TABLE XXIX

SUMMARY OF MULTIPLE CORRELATIONS OF TEST SCORES AND FINAL STANDING IN COMMUNICATION SCHOOL

Course, test, and criterion	N	$R_{1.23}$	$R_{1.234}$
Field Telephone Course:			
GCT and PAT with grade-point average.......	87	.58	-
Pre-Radio Course:			
GCT and PAT with grade-point average.......	74	.69	-
GCT and RTST with grade-point average......	74	.75	-
GCT, PAT, and RTST with grade-point average*..........................	74	-	.83
Radio-Operators' Course:			
GCT and PAT with grade-point average.......	73	.50	-
GCT and RCT with grade-point average.......	73	.58	-
GST, PAT, and RCT with grade-point average..........................	73	-	.80

* Final standings for the Pre-Radio Course computed as modified Z-scores.

TABLE XXI

SUMMARY OF STANDARD ERRORS AND PROBABLE ERRORS OF COMPUTED COEFFICIENTS OF CORRELATION

Test and criterion	N	r	Std. error of r	P.E.
Field Telephone Course:				
GCT scores with grade-point average..........................	87	.51	.080	.054
PAT scores with grade-point average..........................	87	.43	.088	.059
GCT and PAT scores with grade-point average..................	87	.58	.072	.049
Pre-Radio Course:				
GCT scores with grade-point average..........................	74	.40	.098	.066
PAT scores with grade-point average..........................	74	.66	.066	.045
RTST scores with grade-point average..........................	74	.56	.080	.054
GCT and PAT scores with grade-point average..................	74	.69	.061	.041
GCT and RTST scores with grade-point average..................	74	.75	.051	.035
GCT, PAT, and RTST scores with grade-point average............	74	.83	.036	.024
Radio Operators' Course:				
GCT scores with grade-point average..........................	73	.49	.090	.060
PAT scores and grade-point average..........................	73	.28	.107	.072
RCT scores with grade-point average..........................	73	.37	.102	.069
RCT scores with rate of sending code....................	55	.51	.101	.068
RCT scores with rate of receiving code..................	55	.77	.055	.037
GCT and PAT scores with grade-point average..................	73	.50	.088	.060
GCT and RCT scores with grade-point average..................	73	.58	.078	.053
GCT, PAT, and RCT scores with grade-point average............	73	.80	.024	.016

DISCUSSION

The Sample. Table V shows the number of usable scores obtained from a random sample of 100 cases each from the three communication courses under consideration. In the Field Telephone Course 94 per cent of the cases had scores in the General Classification (GCT) and Pattern Analysis Test (PAT), while 81 per cent of the cases in the Radio Operators' Course had GCT and PAT scores. Seventy-three per cent of the cases in the Radio Operators' Course sample had scores for the Radio Code Test (RCT). In the Pre-Radio Course, 87 per cent of the cases had GCT and PAT scores, and 74 per cent had scores in the Radio Technician Selection Test (RTST). While every effort was made to secure a random sample, the sample was biased to some unknown extent because of the missing scores or grades. The nature of this bias is similar to the bias that occurs when all schedules in a questionnaire project are not returned (8 p. 32 f). Because the sample with complete score information represents approximately 20 per cent of the Field Telephone, 17 per cent of the Radio Operators', and 47 per cent of the Pre-Radio Course students for the year 1949, the data can be considered to possess a satisfactory normality to the 1949 population.

Field Telephone Course. While the number of failure cases in the sample is small, the proportionate number of failures ranking in the lower distribution levels of the GCT and PAT is indicated in Table

VI and Table VII. Six failures out of 94 marines have a GCT score of 100 or less while only one scored above 100. Six failures had a PAT score of 101 or less while only one scored above 105.

Tables XII and XIII further demonstrate this relationship. When the top and bottom quarters of the group are analyzed in terms of final grades to the quarter standing of the group in test score distribution, 36 per cent of the sample standing in the bottom quarter had GCT scores in the bottom quarter of test scores, while none were in the top quarter. In contrast, 68 per cent of the sample cases in the top quarter of grade distribution were in the top quarter of the group's GCT score distribution, while none were in the bottom quarter. A similar relationship was found in comparing the standings of the group in relation to PAT score distribution. Fifty per cent of the bottom group were in the bottom quarter standing of PAT scores, with none scoring in the top quarter. Sixty-four per cent of the top quarter grade group were in the top quarter PAT score group, with none in the bottom quarter.

It appears, therefore, that both the GCT and the PAT have a very direct relationship to achievement in the Field Telephone Course in discriminating between the upper and lower quarters of the criterion distribution. When the test-score averages of marines failing in 1949 was compared to the successful group in the sample, Table XX, this hypothesis is further strengthened. The successful group averaged a median score of 111.5 points in the GCT as compared with 102.7 for the failure group. A similar relationship, 111.6 to 102.9, exists for the PAT. This difference is significant since the 99.73 per cent fiducial limits of the GCT score mean of the successful group is 108.5

and 116.3, as compared to a mean of 103.8 for the failing group.[9] The 99.73 fiducial limits of the FAT score mean is 108.1 and 116.3, as compared to the failing group's mean of 105.3.[10]

Table XXIV shows a Pearsonian coefficient of correlation of .51 between the GCT score and grade-point averages in the Field Telephone Course. Twenty-six per cent of the variations in grade-point averages are therefore associated with variations in GCT scores. This correlation is considered to be significantly high for personnel selection practice. The GCT is actually an intelligence test and the finding agrees with Mursell (18 p. 292), who writes, "There is a marked positive relationship between intelligence test scores and school achievement. This centers approximately around a correlation of .50 or perhaps somewhat lower between intelligence and average grade." A correlation of .43 was obtained as the relationship between FAT scores and the criterion. While lower than the GCT relationship, a 19 per cent association of variations is significant. The intercorrelation value between the GCT and FAT scores of the Field Telephone Students was .35 which would indicate a moderate degree of relationship.[11] When the partial coefficient of correlation, Table XXVIII, was computed holding GCT scores constant, the correlation of FAT scores to grade-point average was increased to .49. This significant correlation seems logical because of the apparent requirement for spatial visualization in field telephone communication work.

Twenty-one of the sample cases had test scores in the EMST. While considerable bias is possible in this small sample, the test results

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[9] Refer to the std error of the mean, Table XXI, p. 40.
[10] Ibid.
[11] See Table XXVII, p. 46.

correlated significantly high. A coefficient of .52 with Electricity sub-course grades and .55 with the final grade-point average was computed. The mean of this small sample was within one standard deviation of the mean of the final grade-point average of the entire sample. It would appear that this relationship should be further explored with a significant sample because the RTST, while not used in personnel selection for the Field Telephone Course, provided the highest predictive value of any single measure for this course.

When the scores of the GCT and PAT were compared in combination with the criterion, Table XXIV, a multiple correlation coefficient of .58 was secured. This relationship provided the best predictor for the Field Telephone Course.

Pre-Radio Course. The number of failures in the sample show that a higher percentage of failures, Tables VIII and IX, occurs in the Pre-Radio Course as compared to the Field Telephone and the Radio Operators' Course. The sample shows a failure rate of 18 per cent while the actual failure rate for the year 1949 was 26 per cent of the total Pre-Radio Course population. While the relation between failure and test score is not as striking as that found in the Field Telephone Course, the greater proportion ranked in the lower levels of the GCT score distribution. This pattern exists, to a lesser degree, between failure and the PAT score distribution. When the grade-point average distribution of the sample is compared by top and bottom quarters to quarter standing in test score distribution, Tables XIV, XV, and XVI, a similar relationship is found. Forty-seven per cent of the sample ranking in the bottom quarter of the grade distribution stood in the

bottom quarter of the GCT score distribution, and 16 per cent at the top. At the same time 47 per cent of the group ranking in the top quarter of grade distribution stood in the top quarter of the GCT score distribution, and only five per cent ranked in the bottom quarter.

A similar comparison of grades to PAT scores revealed less discrimination value. Thirty-two per cent of the bottom quarter in grades ranked in the bottom quarter of the PAT score distribution, and 16 per cent ranked at the top. In the top quarter of grade distribution, 53 per cent ranked in the top quarter of PAT scores, and none ranked in the bottom quarter. The comparison showed better discrimination of the top brackets in proficiency, which was generally true.

The RTST effectively discriminated between quarter standings of grades and test scores. Forty-two per cent of the bottom quarter of grade distribution ranked in the bottom quarter of test score distribution, and none stood at the top. Sixty-eight per cent of those in the top quarter in grades ranked in the top quarter of RTST scores, while five per cent stood at the bottom.

The average test scores of marines successfully completing the Pre-Radio Course were compared with the average scores of the group failing the course. The successful group averaged a GCT median of 128.8 while the failing group's median score was 121.3. In the PAT the median of the successful group was 131.3 and the failing group's median was 128.5. This also represents a significant difference because the 99.73 confidence limits of the GCT mean for the successful group is

126.1 and 132.5, as compared to a mean of 121.6 for the failing group.[12] The confidence limits of the mean PAT score for the successful group is 128.4 and 133.4, as compared to a mean of 126.5 for the failure group.

GCT scores correlated, Table XXV, .40 with final standings in the Pre-Radio Course, while PAT scores correlated .66 with the criterion. This demonstrates that, for the sample at least, there was a closer degree of relationship between the degree of success and PAT attainment than with attainment in the GCT. While RTST scores correlated somewhat lower, the correlation of .56 was raised to .80 as a partial correlation holding GCT scores constant. At the same time the PAT relationship in a partial correlation was reduced slightly to .62. The relationship of these test results with the criterion are considered to be particularly significant because although the intercorrelation of GCT and PAT scores was .30, the intercorrelation of RTST scores with GCT and PAT scores was .19 and .11 respectively.[13]

When multiple correlations of the test combinations were computed, Table XXIX, a correlation of .69 was found between the criterion and GCT and PAT scores. A coefficient of .75 was computed for the combination of GCT and RTST scores with the criterion, while a correlation of .83 was computed for the combination of GCT, PAT, and RTST with the criterion. This latter combination was the best predictor on the basis of the available data.

While these tests provide good predictive values for the standings of individuals successfully passing the minimum course require-

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[12] Refer to the std error of the mean, Table XXII, p. 41.
[13] See Table XXVII, p. 46.

ments of the Pre-Radio Course, a high percentage of marines fail to complete this course. RTST scores of the failure group were not available to the writer. However the median GCT and PAT scores stood well above the current critical scores used for selection purposes. Because of the high test averages of at least these two tests, it would appear that certain other factors, such as interest or aptitude, may be significantly correlated with success or failure in this more difficult curriculum. A correlation of RTST scores with grade-point averages, including the failures, would be most desirable for more effective study of this group.

Radio Operators' Course. The relationship of the failures to test-score distribution, Tables X and XI, was similar to the relationship found in the Pre-Radio Course. Six out of the eight failures in the sample had a GCT score of 114 or less, while the entire eight scored 114 or below in the PAT. A very direct relationship was found when the top and bottom quarter standings in grades were analyzed in terms of quarter standings of the group in test scores, Tables XVII, XVIII, and XIX. Sixty-three per cent of the group ranking in the bottom quarter of grade distribution scored in the bottom quarter of the GCT score distribution, while none were in the top quarter. At the same time 58 per cent of the top quarter grade group were in the top quarter of test scores, while none scored in the bottom.

Forty-seven per cent of the bottom quarter in grades scored in the bottom quarter of the PAT scores, and 11 per cent scored in the top. A better relationship was found in the top quarter grade group where 63 per cent ranked in the top quarter PAT score distribution, and

none scored in the bottom. A similar comparison with RCT scores revealed that 53 per cent of the bottom quarter standing in grades ranked in the bottom quarter of RCT scores, while only five per cent ranked in the top quarter. Sixty-three per cent of the top quarter in final grade-point average ranked in the top quarter of RCT scores, and 11 per cent ranked in the bottom quarter.

A relationship between average GCT and PAT scores of the successful group and failure group, Table XX, was found similar to the results in the preceding communications courses. The median GCT score for the successful marines was 116.3 while the failure group scored a median of 110.4. The PAT median of the successful sample was 116.2 and the median of the failure group was 109.3. The significance of this relationship is shown by the fact that the 99.73 per cent confidence limits of the successful sample's GCT mean is 112.4 and 120.6, as compared to a mean of 111.6 for the failure group.[14] The confidence limits of the sample group's PAT mean is 111.6 and 118.8, as compared to a mean of 109.5 for the failure group.

Table XXVI summarizes the Pearsonian correlations determined for the Radio Operators' Course. A correlation of .49 was found between GCT scores and the criterion. A correlation of .28 between PAT scores and the criterion shows the lowest association with this test. While the RCT correlated only .37 with the final grade-point average, the relationship between RCT scores and the qualified rate of receiving radio code in words per minute, was high with a coefficient of .77. A coefficient of correlation of .51 was found between RCT scores and the qualifies rate of sending radio code. The RCT is

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[14] Refer to the std error of the mean, Table XXIII, p. 42.

an auditory test measuring the speed of response. It is apparent that a higher correlation should exist between it and the radio code reception rate because efficient code reception requires auditory perception of a high order. On the other hand it appears probable that finger dexterity is related to some degree with facility in sending radio code.

RTST scores were available for 30 of the Radio Operators' Course cases. A correlation of .37 was found between RTST scores and the grade-point average of the Radio Equipment sub-course. This relationship shows that 13 per cent of the variations in sub-course grades are associated with variations in RTST scores. The possibility of the existence of considerable bias, because of the small size of the sample, further reduces the significance of this finding.

An intercorrelation of .32 was found between GCT scores and the PAT scores. This relationship is very close to the correlations found between these tests for the other courses in communication under study.[15] The intercorrelation of GCT scores to RCT scores is .13 while the intercorrelation between PAT and RCT scores is -.12. These low intercorrelations show that the tests probably measure different abilities or capacities and are therefore desirable for making up the test battery.

When partial correlations holding GCT scores constant were computed, Table XXVIII, a coefficient of correlation of .15 was found for the relationship of PAT scores with grade-point averages. This drastically reduces the predictive value of the PAT for this course as a single predictor. The partial correlation of RCT scores with the

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15. See Table XXVII, p. 46.

grade-point average is .36, practically the same as the simple correlation relationship.

The computed multiple correlation relationships are shown in Table XXIX. The combination of GCT scores and PAT scores with the criterion gives a correlation of .50, while combining GCT and RCT gives a correlation of .58. A multiple correlation of .80 is obtained when GCT, PAT, and RCT scores are correlated with the grade-point average. The combination is the best association of individual predictors for the Radio Operators' Course.

General. Throughout this discussion correlation values having relatively low coefficients of determination have been classified as significant predictors of the established criteria. A relatively high predictive value can be attached to correlations in personnel study of groups where the groups are homogeneous in nature. A selective process has limited the lower levels of test scores in this study, which in turn reduces the range of test score values and therefore further reduces the measurable correlation. It is reasonably certain that if samples from the entire marine recruit population, regardless of test-score attainment, were permitted to take the communication school training, the correlation of test scores to grade-point average would be significantly increased. Cronbach (7, p. 260) sums up the effect of restriction of range by stating, "Validity coefficients rise when a test is applied to a group with a wide range of ability, and drop when the test is used on a restricted, pre-selected group." Tiffin (25, p. 66) writes:

> ... a test will be valuable, no matter how low the coefficient of validity, if it indicates some relationship between test scores and the criterion; or, in statistical terms, if the coefficient of validity is at least four times its probable error. Often this will admit tests whose validity is as low as .30 or even lower.

Table XXX summarizes the standard errors and probable errors of the various coefficients of correlation obtained for the three communication courses. With the single exception of the coefficient obtained between PAT scores and the criterion for the Radio Operators' Course, all coefficients exceed four times the value of their probable error.

While the correlations of the tests are generally not sufficiently high in value to permit satisfactory individual prediction, the relationships are high enough to employ the selection ratio technique (25, p. 66 ff), or the critical-score method (7, p. 249 ff). Analysis of the relationships shown in Tables XII to XIX inclusive and Appendix B, indicate the feasibility of using these procedures. It would appear desirable to select and place marines in the communication schools on the basis of a selection ratio technique, employing such tables as those prepared by Taylor and Russell(24). The use of this technique would aid in placing the best number of marine recruits most likely to succeed in a particular course, according to the ratio of available recruits to the quota of students required.

SUMMARY AND CONCLUSIONS

Summary. Since the beginning and classic work of Alfred Binet in 1905, the development and application of psychological testing for practical purposes has advanced rapidly. While reports of the successful employment of testing techniques in the Army during World War I stimulated the application of psychological testing in business and industry, the greatest use of testing took place during World War II. During the single year of 1944 over twenty-four million tests were administered in the armed forces to some four million men.

The studies illustrating the utilization of psychological tests for selection and placement are many and varied. They range in nature from industrial workers through the selection and placement of psychologists, salesmen, scientists, and teachers. Testing occupies a prominent place in the Naval Service. The Marine Corps employs a test battery which is given to all recruits at the recruit depots. This battery includes the General Classification Test, of which the Pattern Analysis Test is a part, a Clerical Aptitude Test, a Radio Code Test, and the Radio Technician Selection Test.

After completion of recruit training, marines are assigned to duty on the basis of individual desires and the results of the test battery. For selection to the Marine Corps communication schools, the recruit must score a minimum of 90 in the General Classification and Pattern Analysis Test for assignment to the Field Telephone

Course. For assignment to the Pre-Radio Course, the recruit must score a minimum of 110 in the General Classification and the Pattern Analysis Test and 35 in the Radio Technician Selection Test, while a minimum score of 100 in the General Classification and Pattern Analysis Test and 130 in the Radio Code Test is required for assignment to the Radio Operators' Course.

The requirements for skilled communication specialists is growing and will continue to grow in the forseeable future. The Marine Corps must draw its neophyte communicators from a rather homogeneous recruit group having a mean age of 18.8 years. It is essential, therefore, on a basis of cost and military efficiency, to use the best possible predictors for selecting candidates for communication training. The best prediction methods must be developed prior to any general mobilization in the event of armed conflict. While studies were made of the predictive value of various tests for similar communication schools in the Navy during World War II, the recruit population of that period covered a much wider distribution in age and experience. The purpose of this study is, therefore, to determine the effectiveness of the test battery in predicting the success of marine recruits selected for training at the Marine Corps communication schools, and to make recommendations for the improvement of future selection techniques on the basis of these findings.

A random sample of 100 cases each was obtained for the Field Telephone, Pre-Radio, and Radio Operators' Course. Each case included the value of the individual's test results, his final grade-point average or standing in class, and his grades in sub-course subjects.

This sample was taken from the 1949 school population to insure a constant curriculum and selective criteria. At the same time data were secured for all the individuals failing these communication courses during the period. Unfortunately, due to administrative difficulties beyond the writer's control, test scores or other data were not available for all cases in the sample and bias, similar in nature to that which occurs when all schedules in a questionnaire survey are not returned, was present to some unknown degree. Because the sample is relatively large in proportion to the population, this bias should be small.

The grade-point average attained at school was selected as the criterion measure. Grades are assigned at the school on the basis of standardized tests plus, to a lesser degree, instructors' ratings of certain field work. A reasonable level of validity and reliability was assumed, therefore, for the grading system. In addition, a secondary criterion, the rate of sending and receiving radio code, was adopted for the Radio Operators' Course.

The data were treated by making direct comparisons of test scores to success or failure, and by comparing the top and bottom quarters in grade-point distribution with the quarter standing of the group in test-score distribution. The data were also statistically treated to determine simple, partial, and multiple correlations of test score relationships to the criterion.

Analysis revealed that both the General Classification Test (GCT) and the Pattern Analysis Test (PAT) discriminated between the success and failure of students in the Field Telephone Course. While the

successful group averaged a GCT median score of 111.5, the failure group averaged a median of 102.7, and a similar relationship of 111.6 to 102.9 was found for the PAT. A Pearsonian coefficient of .51 was computed for the GCT with grade-point average, and the PAT correlated .43 with grades. In a multiple correlation of the GCT and PAT, a coefficient of .58 was obtained, indicating a significant predictive relationship. Twenty-one of the cases had Radio Technician Selection Test (RTST) scores which correlated .52 with the sub-course in Electricity and .55 with the grade-point average.

In the Pre-Radio Course, GCT scores were effective in discriminating between success and failure while the PAT was somewhat less efficient in discriminating value. The median GCT and PAT score of the successful group was 128.5 and 131.3 respectively, while the failing group scored 121.3 and 128.5. GCT scores correlated .40 with the criterion and the PAT correlation was .66. While RTST scores correlated .56, the partial correlation, holding GCT scores constant, was .80 and the PAT correlation was reduced to .62. A multiple correlation of .69 was found between the criterion, GCT, and PAT scores, and .75 by combining GCT and RTST scores. When all three tests were combined, the correlation was .83, indicating a high predictive value for the test battery.

Results similar in nature to the findings in the other courses were found in the direct relationship of test scores to success or failure in the Radio Operators' Course. The median GCT and PAT score for the successful group was 116.3 and 116.2 while the failing group scored 110.4 and 109.3 respectively. GCT scores correlated .49 with

the criterion and the PAT correlation was only .28, a rather low correlation. This coefficient was further reduced to .15 as a partial correlation when GCT scores were held constant. While the Radio Code Test (RCT) correlated only .37 with the criterion, it correlated .77 with the speed of receiving code and .51 with code transmission. In combination the GCT and PAT scores produced a coefficient of multiple correlation of .50, while the combination of GCT and RCT scores correlated .60. Combining all the tests with the criterion produced a correlation of .80, an excellent predictor for group personnel practice.

Increased significance can be attached to these relationships because the data is representative of a homogeneous group with a restrictive range of test and grade-point scores. A significant increase in the value of the coefficients could be expected if recruits were sent to communication school without prior selection so that a full range of scores would be available for comparison.

Conclusions. In order to evaluate the effectiveness of the psychological tests used in selecting recruits for training at the Marine Corps communication schools, the component tests of the basic test battery administered at recruit depots have been statistically analyzed. These tests, the General Classification Test, the Pattern Analysis Test, the Radio Code Test, and the Radio Technician Selection Test, are used to assign marine recruits to the Field Telephone, the Pre-Radio, and the Radio Operators' Course.

The General Classification Test and The Pattern Analysis Test are used as a selective battery for the Field Telephone Course. The

best single predictor is the General Classification Test with a validity coefficient of .51. The best predictor is a combination of the two tests, with a correlation coefficient of .58.

The General Classification Test, the Pattern Analysis Test, and the Radio Technician Selection Test are used as a selective battery for the Pre-Radio Course. The best single predictor is the Radio Technician Selection Test with a correlation of .80 determined through partial correlation holding General Classification Test scores constant. The Pattern Analysis Test ranks as the next best single predictor with a partial correlation of .62. The three tests in combination produce the most effective battery with a correlation of .83. While the predictive value is high for the relative standings of the successful students in the course, a large percentage, 26 per cent, failed to successfully complete the course. Predictive measures must be developed to reduce the number of failures in this more difficult curriculum.

The General Classification Test, Pattern Analysis Test, and the Radio Code Test are used as a selective battery for the Radio Operators' Course. The best single predictor of this battery is the General Classification Test with a validity coefficient of .49. While the Radio Code Test correlates low with the final grade-point criterion, it correlates fairly high with the attained rate of receiving and sending radio code, .77 and .51 respectively. The combination of the three tests, however, provides a good predictor with a multiple coefficient of correlation of .80. This battery is an efficient combination.

In general, additional, evidence of possible test relationship to the established criteria, is desirable. The relation of components of

the General Classification Test, other than the Pattern Analysis Test, should be correlated to determine whether a significant relationship exists between reading and vocabulary, arithmetic computation, and arithmetic reasoning, and the individual course criterion. In addition the significance of interest and mechanical dexterity to these courses should be explored. The most desirable instrument would be one, specifically designed for a particular curriculum, which could accurately discriminate between probable success or failure of the members of the group eligible for assignment under current selective methods.

Recommendations:

(1) Since Radio Technician Selection Test Scores correlate higher with the criterion in a small sample of the Field Telephone Course than any single test now employed, analysis should be made with a truly representative sample to determine the feasibility of using this test as a predictor.

(2) The best combination of the tests currently used for selection purposes was found to be the test batteries now employed at recruit depots. Critical scores for the individual tests should be computed from the multiple regression equation of each test battery.

(3) The selection ratio technique should be employed at recruit depots to select individuals most likely to succeed in relation to the available population and the various communication school quotas.

(4) The relation of manipulative dexterity to success in communication school should be explored.

(5) The relation of a reliable test of interest in radio and electricity should be correlated with the criteria of the courses to determine the usability of such a test as a predictor.

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APPENDIX A

MARINE CORPS QUALIFICATION FORM

CIVILIAN BACKGROUND

EDUCATION

TYPE OF SCHOOL	NAME AND LOCATION	MAJOR SUBJECT	NUMBER OF YEARS	GRADUATED		DEGREE	YEAR LEFT SCHOOL
				Yes	No		
ammar School		▨		▨	▨	▨	
gh School						▨	
llege or University							
ade—Business							

CIVILIAN OCCUPATIONS

(Main Occupation)			*(Secondary Occupation)*		
B TITLE			JOB TITLE		
ST YEAR EMPLOYED	YEARS EXPERIENCE	CIVILIAN CODE NO.	LAST YEAR EMPLOYED	YEARS EXPERIENCE	CIVILIAN CODE NO.
ME AND ADDRESS OF EMPLOYER			NAME AND ADDRESS OF EMPLOYER		
TIES PERFORMED:			DUTIES PERFORMED:		

LANGUAGES

LANGUAGE	DIALECT	SPEAKS	READS	WRITES	TRANSLATING EXP.		INTERPRETING EXP.	
					Yes	No	Yes	No

FOREIGN RESIDENCE

CITY OR SUBAREA	COUNTRY	DATES OF RESIDENCE		REASON	USED LANGUAGE	
		From—	To—		Yes	No

SPORTS		HOBBIES	
SPORT	EXPERIENCE	HOBBY	EXPERIENCE

OPERATES (Name of Machine, Vehicle, Equipment, etc.)	TALENT FOR ENTERTAINMENT (Musical, Singing, Theatrical)

PREFERENCES FOR DUTY	ASSIGNMENTS RECOMMENDED
2.	1. 2.

REMARKS	CLASSIFICATION APTITUDE AND TRADE TESTS			
	TEST	FORM	DATE	GRADE—SCORE

(LAST NAME) (First) (Middle) (Serial No.)

Mail duplicate to: THE DIRECTOR OF PERSONNEL, HEADQUARTERS, U. S. MARINE CORPS

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APPENDIX B

SCATTER DIAGRAMS SHOWING THE DIRECT RELATIONSHIP OF TEST SCORES TO THE CRITERION

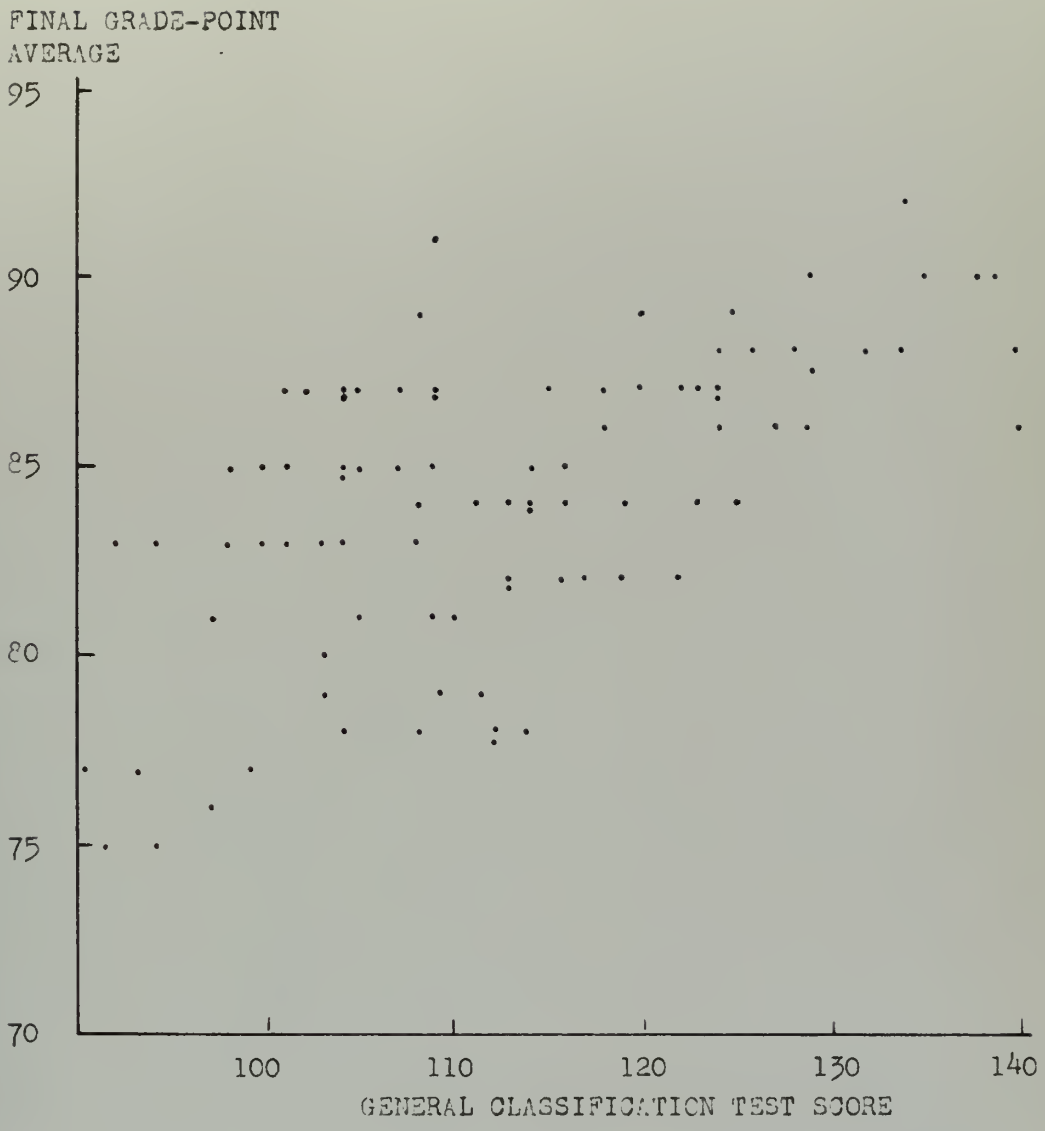

Fig. 1. Relation Between General Classification Test Scores and Final Standing of 87 Marines in the Field Telephone Course.

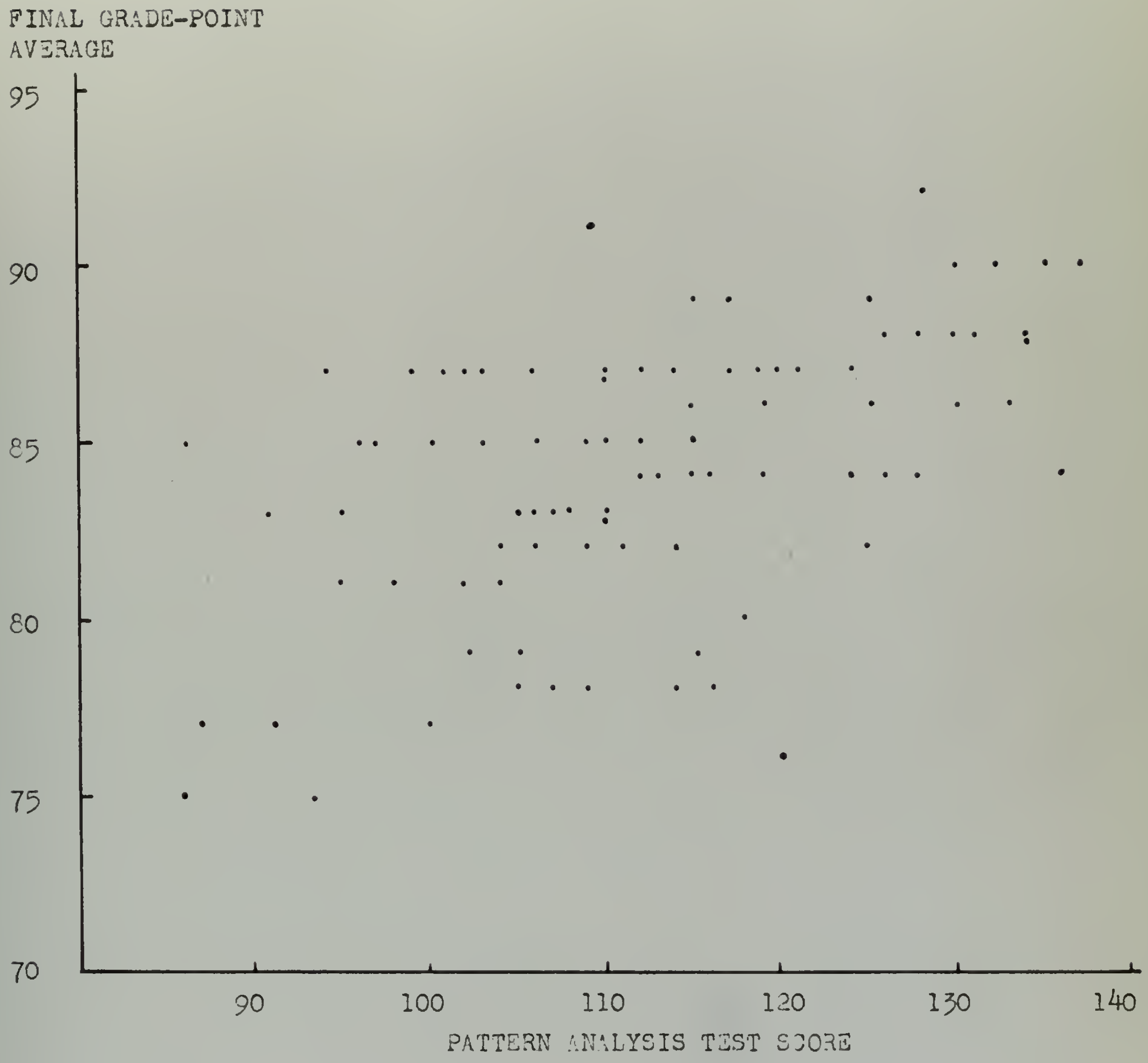

Fig. 2. Relation Between Pattern Analysis Test Scores and Final Standing of 87 Marines in the Field Telephone Course.

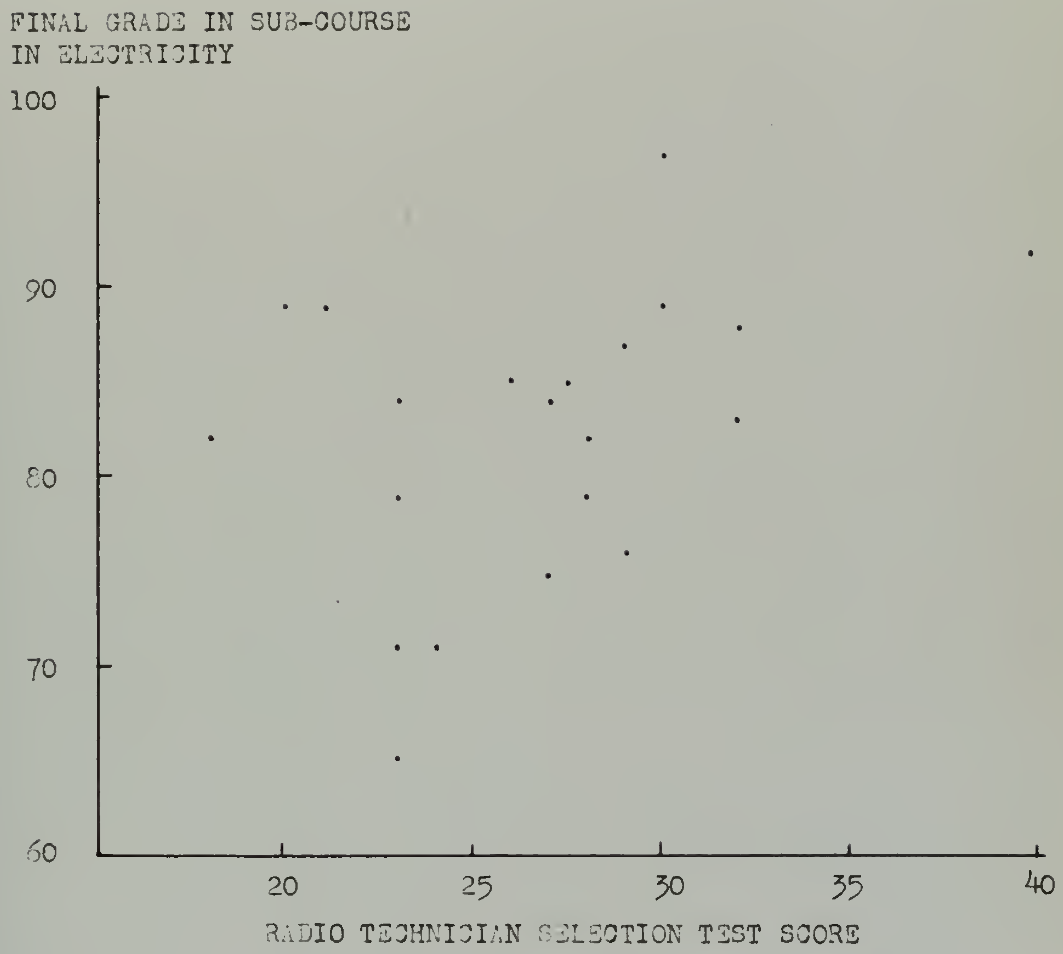

Fig. 3. Relation Between Radio Technician Selection Test Scores and Final Standing of 21 Marines in the Electricity Sub-Course of the Field Telephone Course.

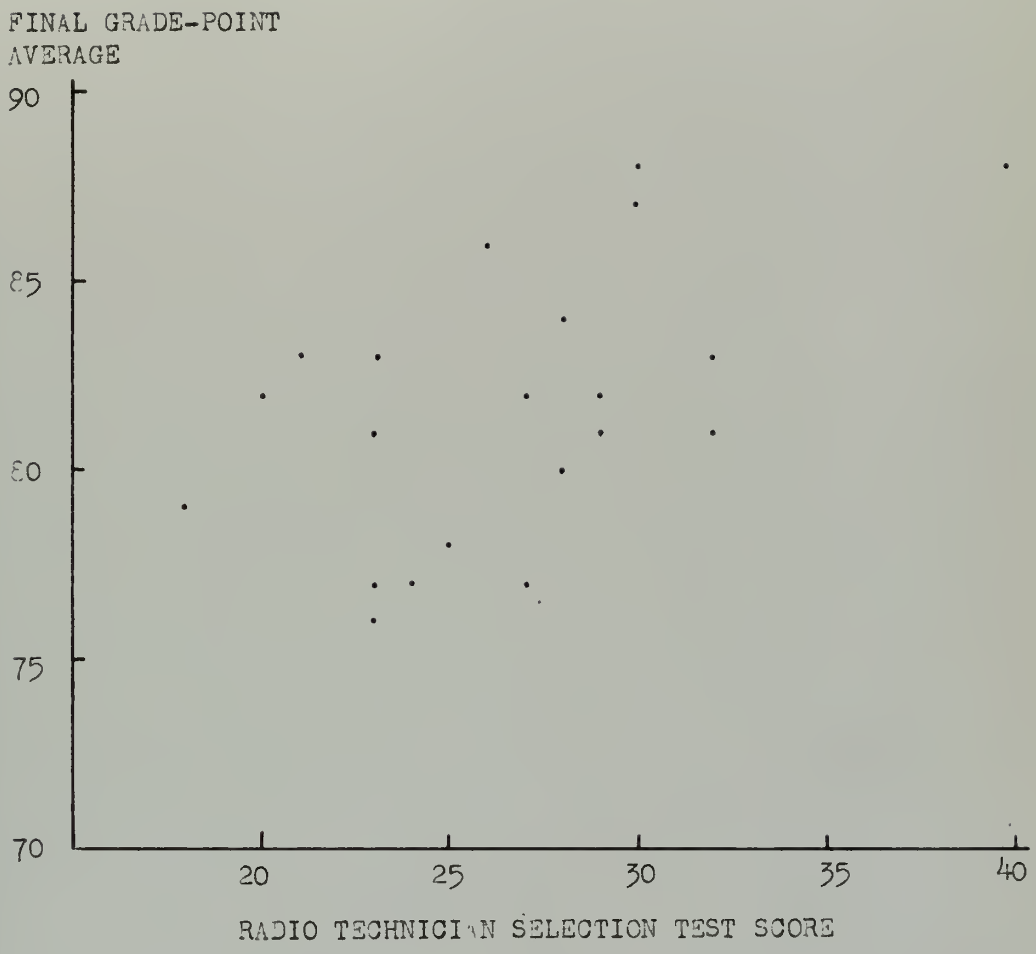

Fig. 4. Relation Between Radio Technician Selection Test Scores and Final Standing of 21 Marines in the Field Telephone Course.

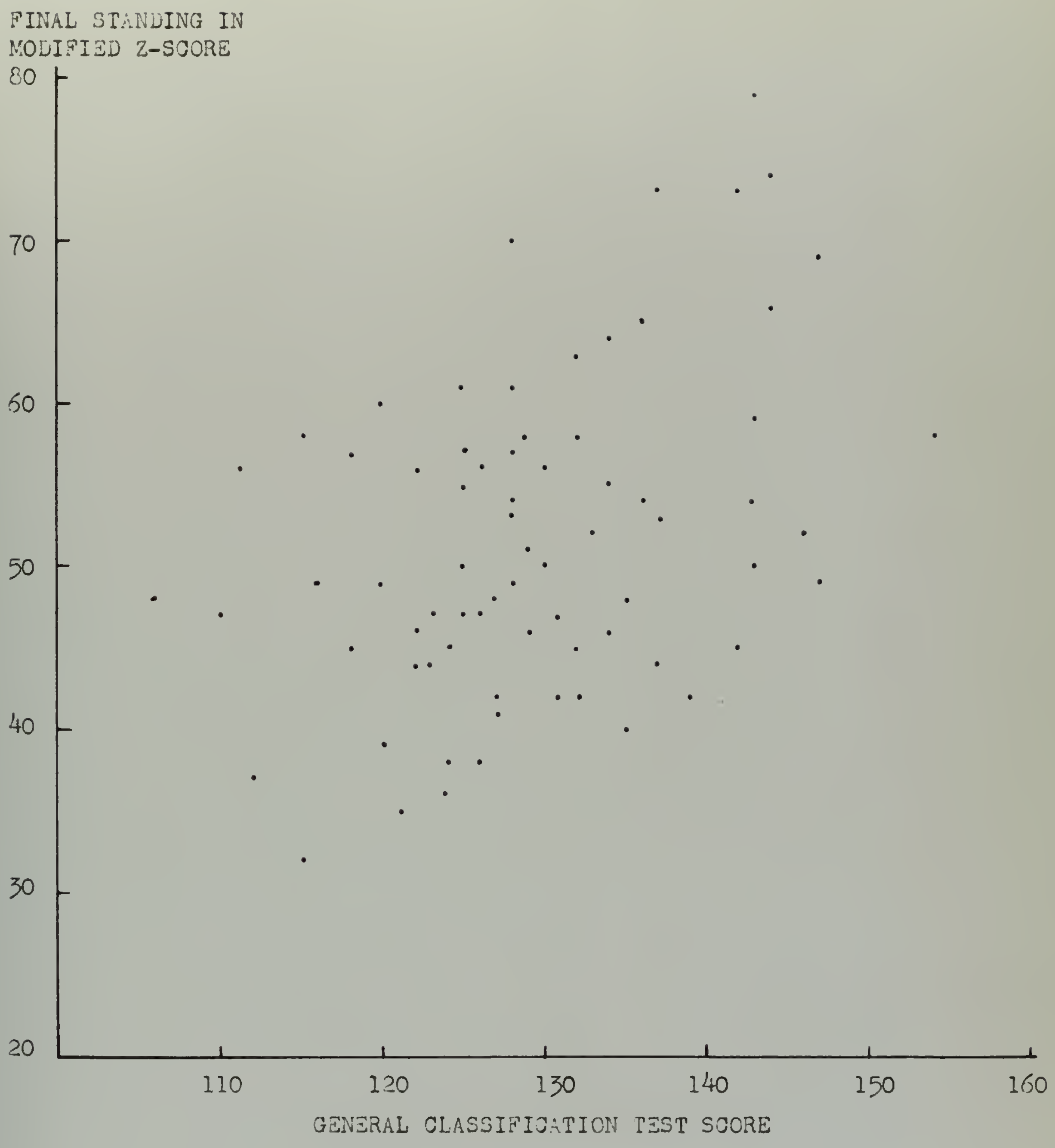

Fig. 5. Relation Between General Classification Test Scores and Final Standing of 74 Marines in the Pre-Radio Course.

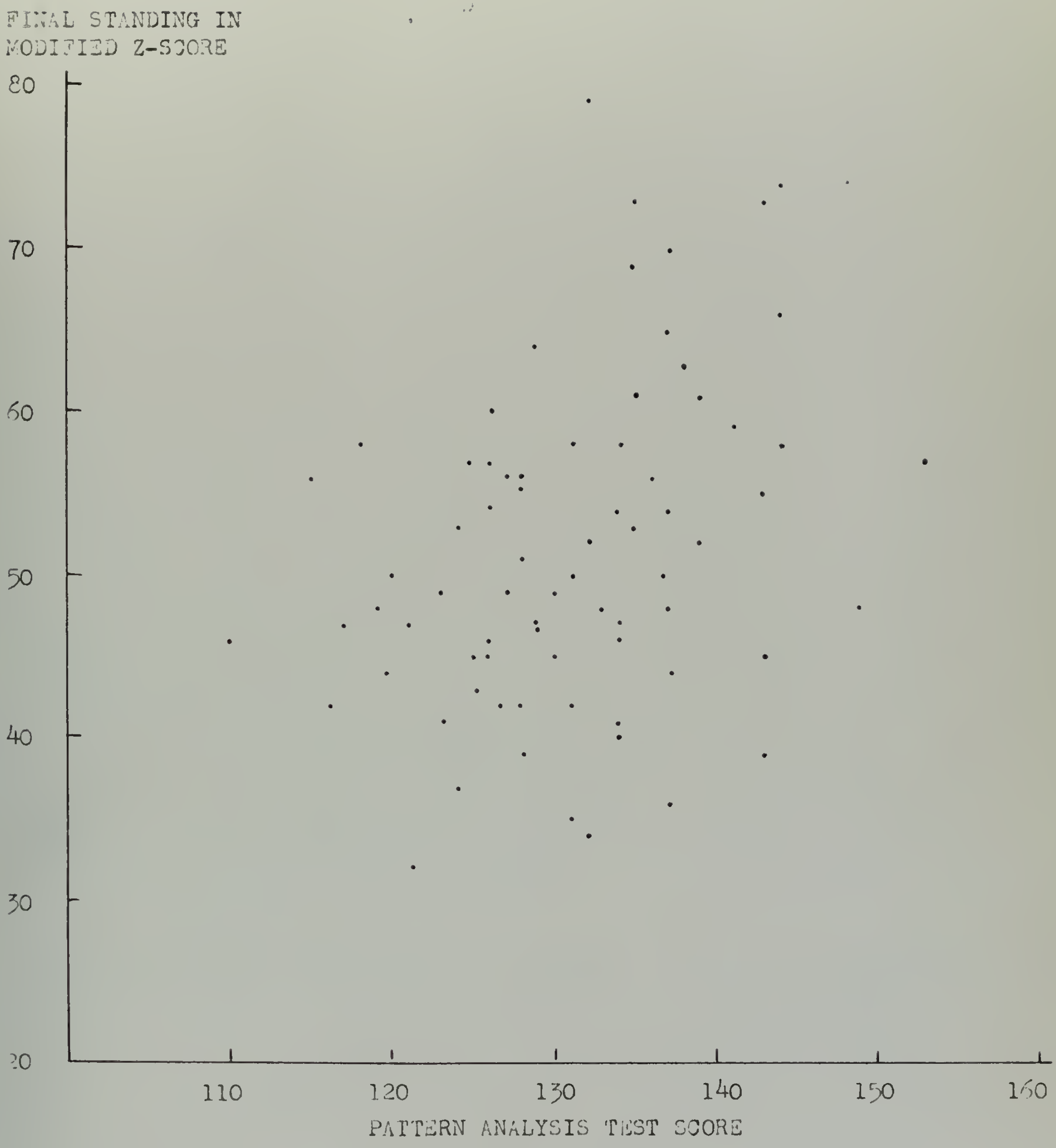

Fig. 6. Relation Between Pattern Analysis Test Scores and Final Standing of 74 Marines in the Pre-Radio Course.

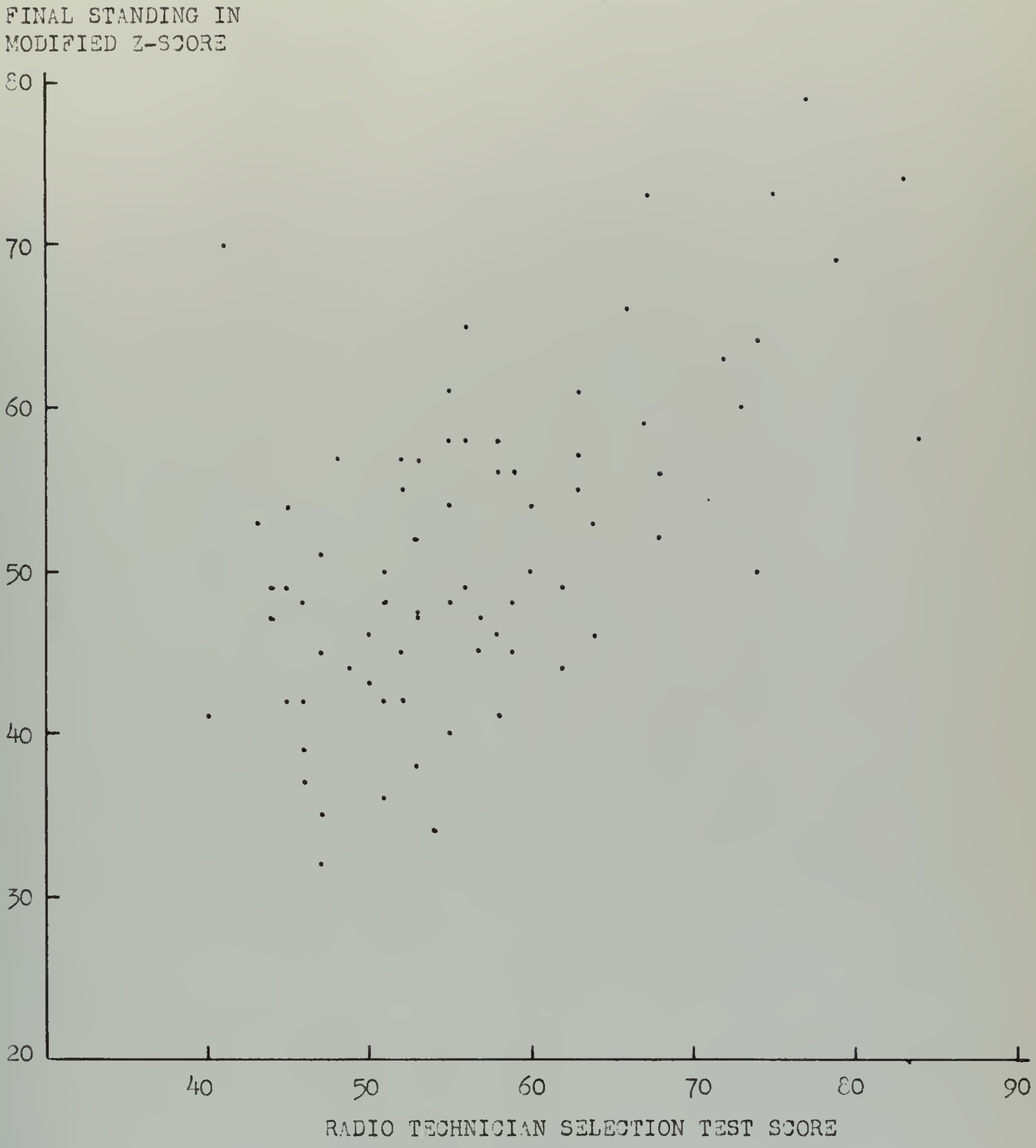

Fig. 7. Relation Between Radio Technician Selection Test Scores and Final Standing of 74 Marines in the Pre-Radio Course.

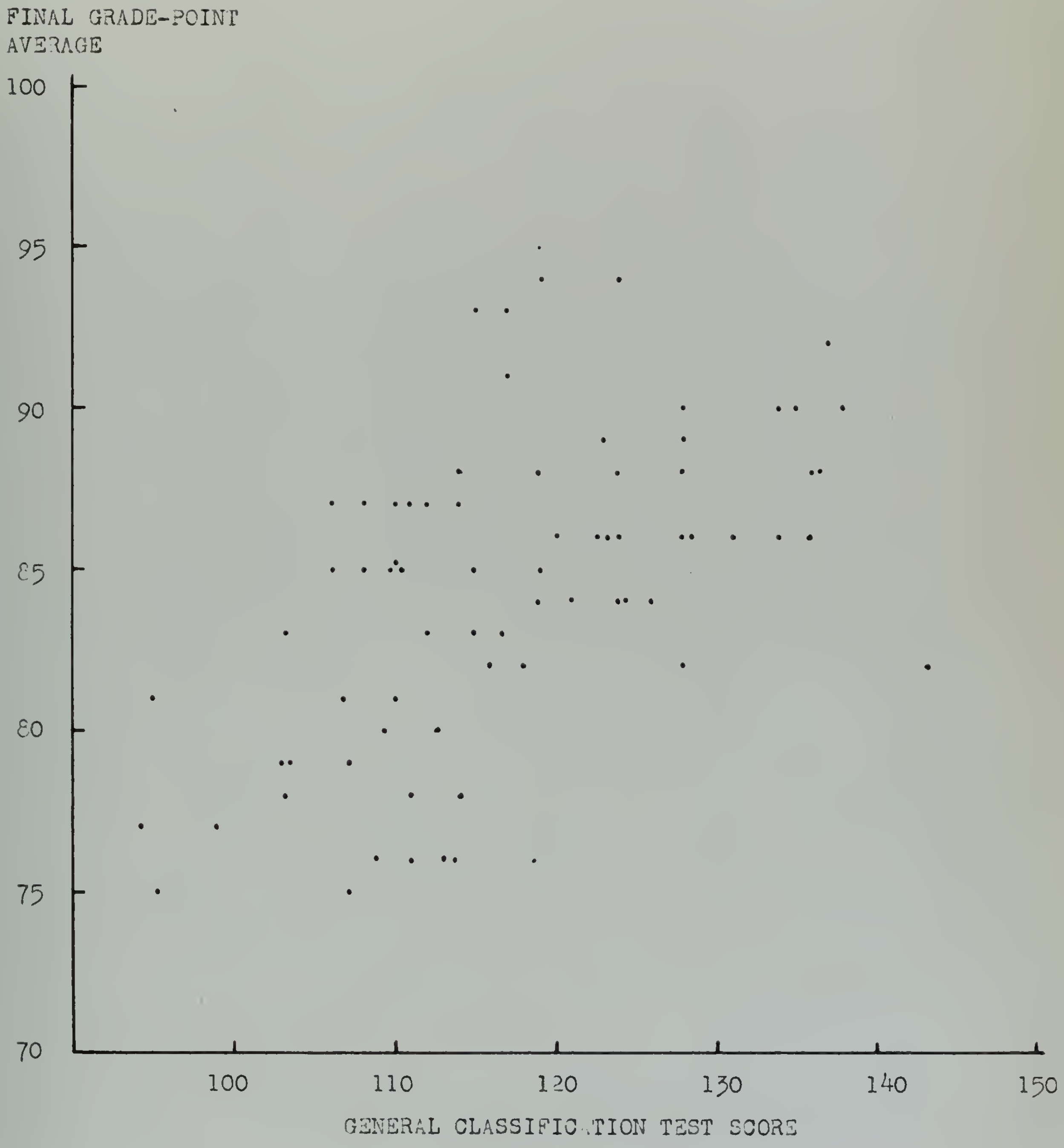

Fig. 8. Relation Between General Classification Test Scores and Final Standing of 73 Marines in the Radio Operators' Course.

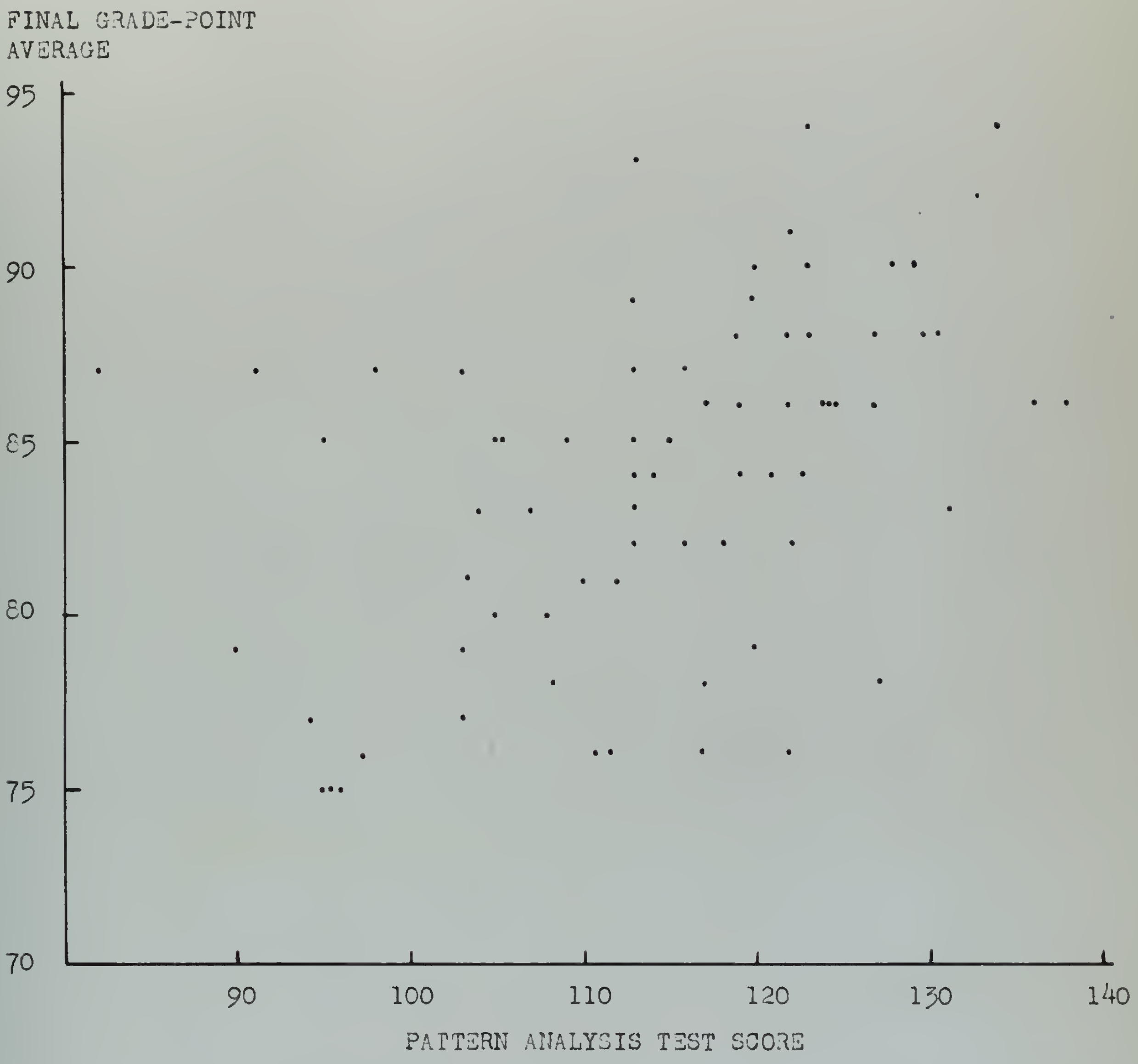

Fig. 9. Relation Between Pattern Analysis Test Scores and Final Standing of 73 Marines in the Radio Operators' Course.

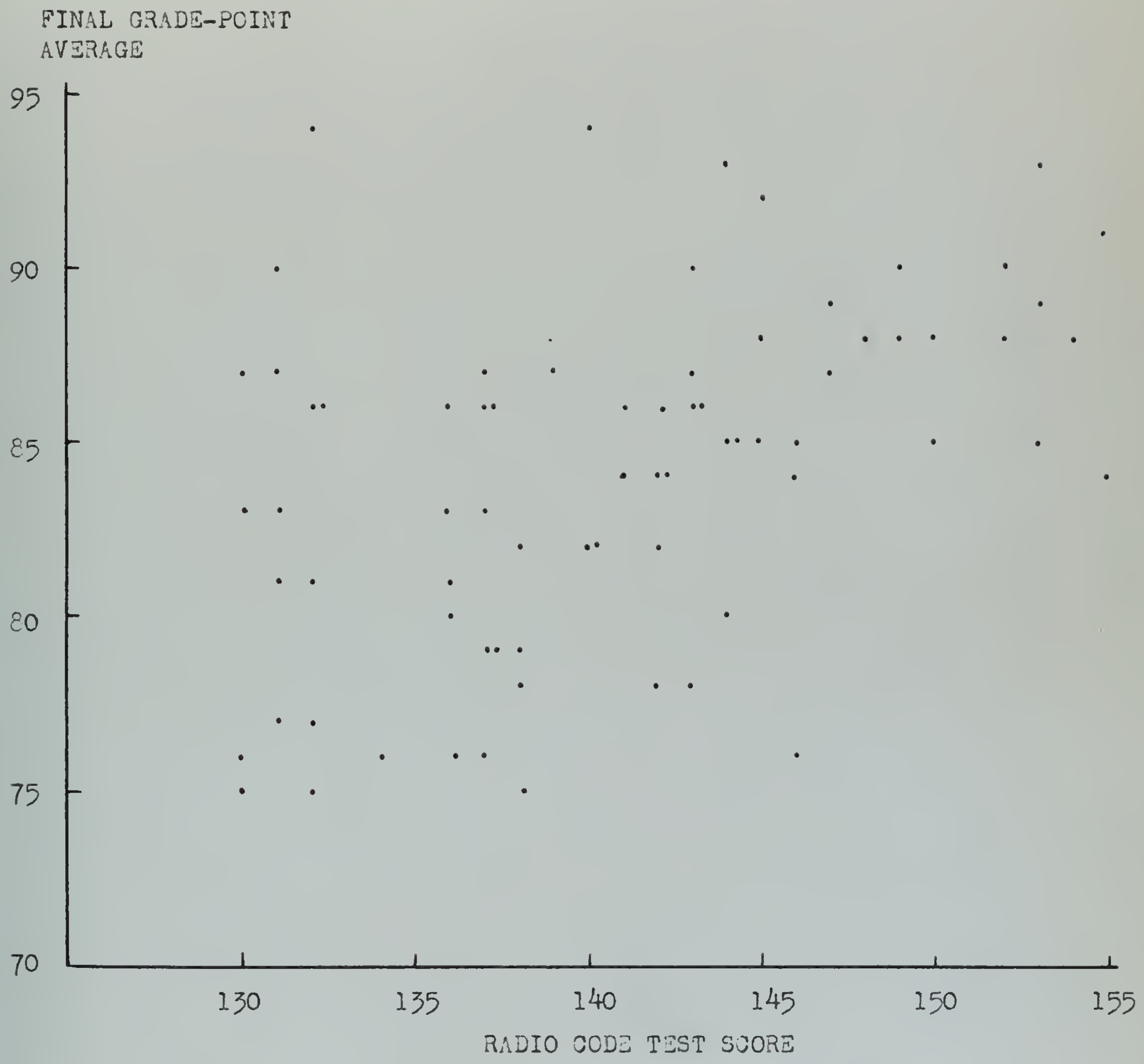

Fig. 10. Relation Between Radio Code Test Scores and Final Standing of 73 Marines in the Radio Operators' Course.

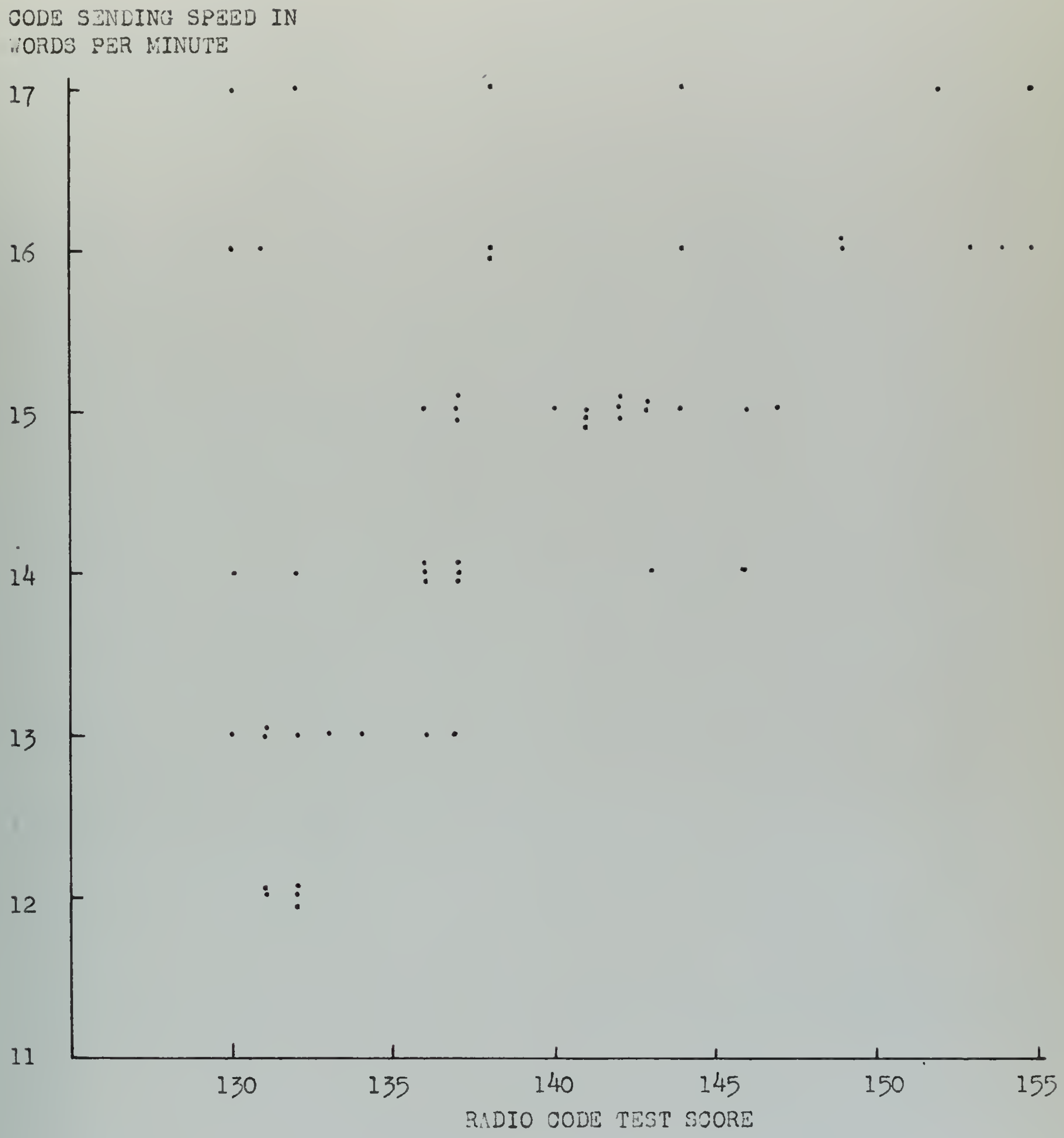

Fig. 11. Relation Between Radio Code Test Scores and Code Sending Speed of 55 Marines in the Radio Operators' Course.

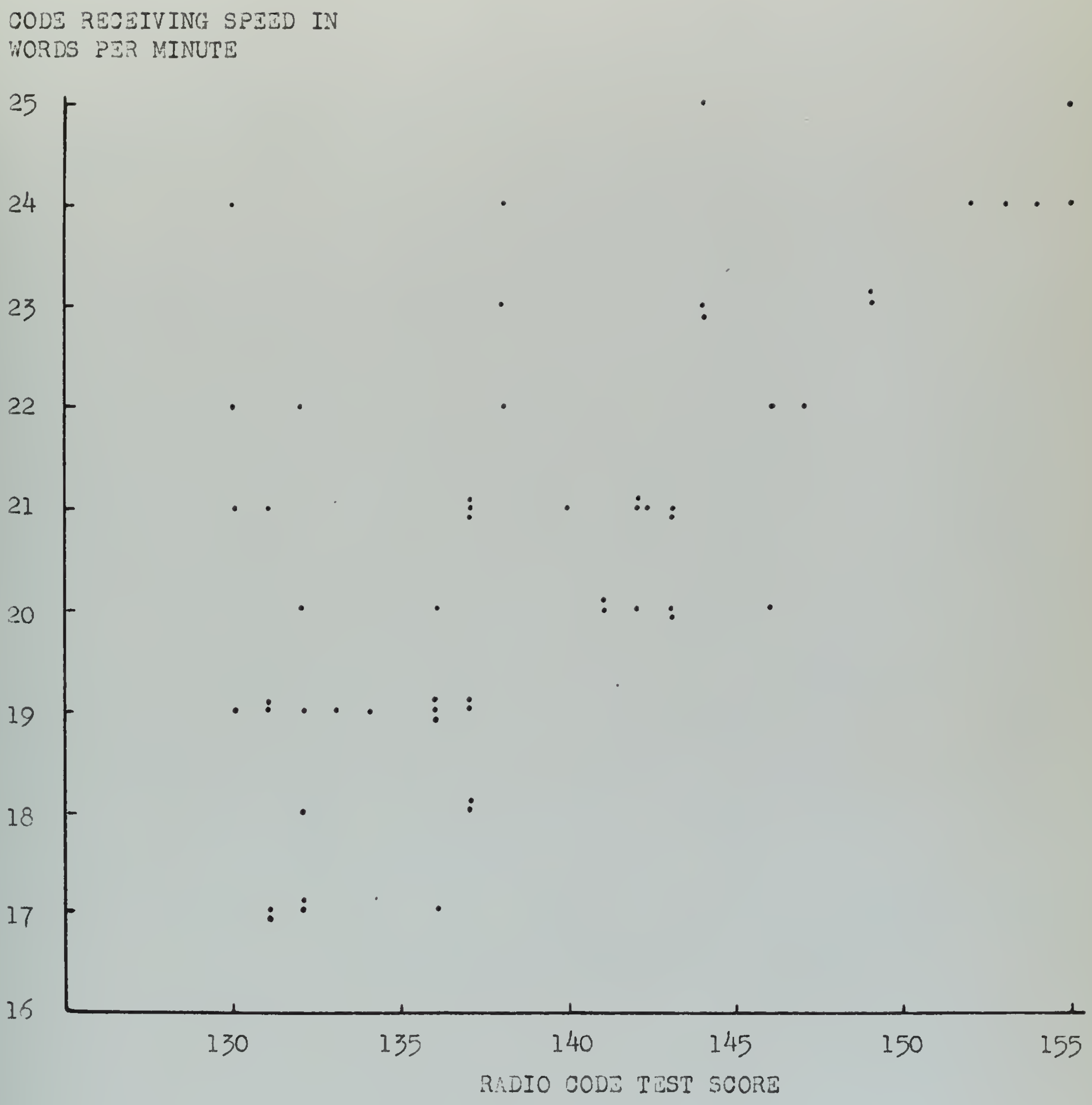

Fig. 12. Relation Between Radio Code Test Scores and Code Receiving Speed of 55 Marines in the Radio Operators' Course.

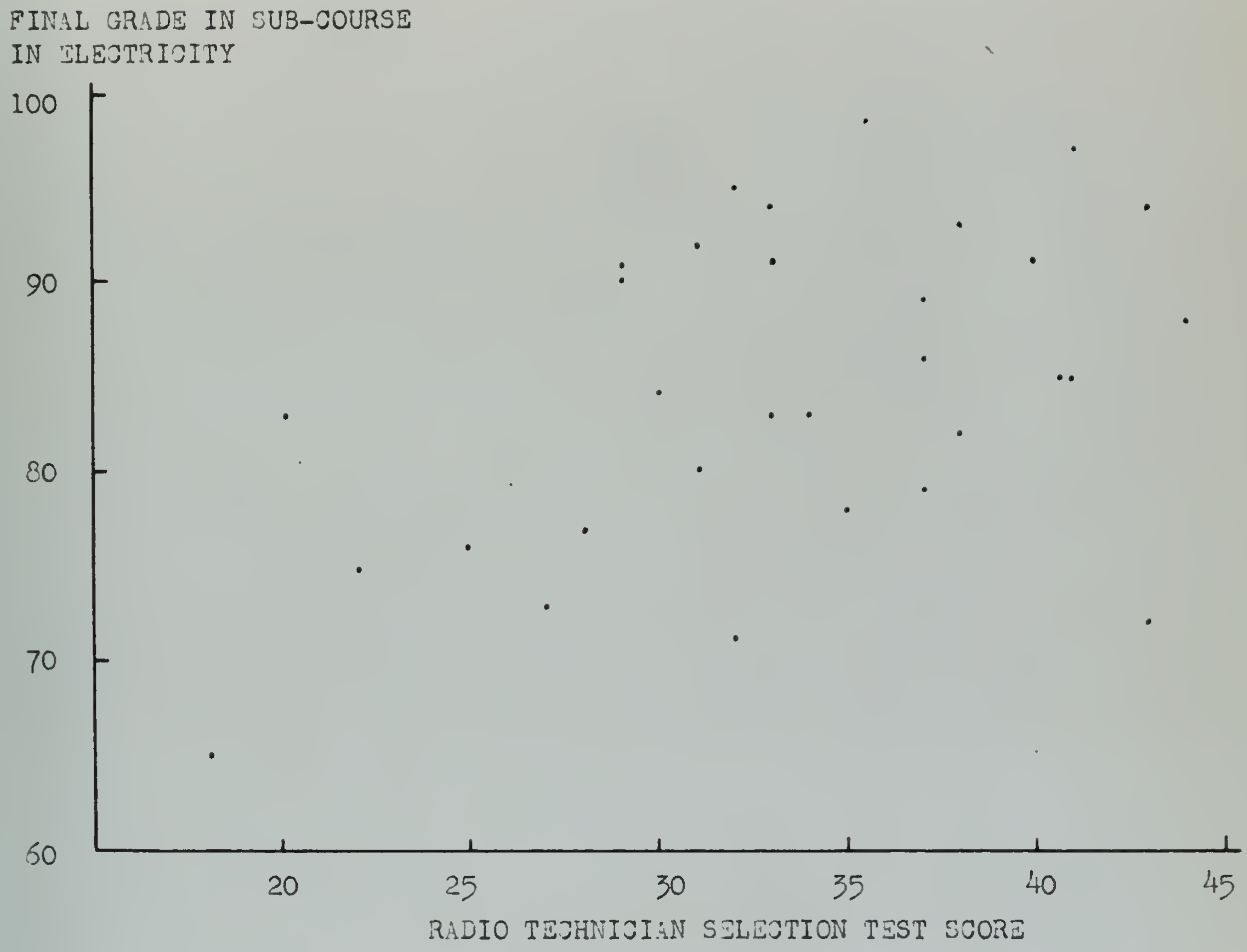

Fig. 13. Relation Between Radio Technician Selection Test Scores and Final Standing of 30 Marines in the Radio Equipment Sub-Course of the Radio Operators' Course.

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